Autumn Scientific Meeting
1st – 2nd October 2010:

Congenital and Hereditary Diseases of Dogs and Cats

Sponsored by:

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Our sponsors and their stands will be situated in the Darwin Suite, next door to the Newton Suite, on both days - coffee and tea will be served at this location at the appropriate times.

**Punting**

- Meet at the hotel reception at 1750hrs to leave at 1800hrs
- Turn RIGHT out of the hotel
- Take the FIRST LEFT into Downing Street, which becomes Pembroke Street
- Go STRAIGHT ACROSS Trumpington Street into Mill Lane, and walk to the river at the end – Scudamore’s Punting is to your right, on the river, next to The Anchor pub
## Full Programme

### FRIDAY 1st OCTOBER

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SATURDAY 2nd OCTOBER

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9.00-9.30  Tools of the Trade: Interventional Radiology  Chick Weisse
9.30-10.15  Everything You Need To Know about Coils and Shunts  Chick Weisse
10.15-10.35  Medical Management: Condemned For Life?  Michael Herrtage
10.35-10.50  Coffee
10.50-1.00  Portosystemic Shunts II
10.50-11.10  Why do they Fit, and What Can We Do about it?  Vicky Doyle
11.10-11.30  Imaging of Portohepatic Abnormalities  Tobias Schwarz
11.30-11.50  Evidence Base for the Surgical Treatment of Shunts  Mickey Tivers
11.50-12.10  Can We Prognosticate about Shunts?  Karla Lee
12.10-12.30  Portosystemic Shunts in Cats  Vicky Lipscomb
12.30-12.50  Out with the New and In with the Old: Intrahepatic Shunt Surgery  Dan Brockman
12.50-1.00  Panel Discussion:  
  Vicky Doyle, Tobias Schwarz, Mickey Tivers, Karla Lee,  
  Vicky Lipscomb and Dan Brockman

1.00-2.00  Lunch
2.00-3.45  Cardiovascular Disease I
2.00-2.20  Imaging the PRAA Puppy – How and Why?  Tobias Schwarz
2.20-2.45  Congenital Cardiovascular Defects: Which to Fix, and When?  David Connolly
2.45-3.30  Plugging the Gap: Interventional Radiology and Congenital Cardiovascular Disease  Chick Weisse
  Panel Discussion:  
  Tobias Schwarz, David Connolly and Chick Weisse

3.45-4.00  Coffee
4.00-5.15  Cardiovascular Disease II
4.00-4.30  Keep Her Ticking Over: What can be achieved without Bypass?  Dan Brockman
4.30-5.00  Veterinary Open Heart Surgery using Cardiopulmonary Bypass: Past, Present and Future  Dan Brockman
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Beyond Ligating a PDA: Surgery that carries a Health Warning!
Dan Brockman
Speaker Profiles

Daniel Brockman
BVSc CVR CSAO Diplomate ACVS/ECVS FHEA MRCVS


Dan moved to the University of Pennsylvania in 1991 as a Lecturer in Surgery and where he became Assistant Professor of Surgery in 1994. He became a diplomate of the American College of Veterinary Surgeons in 1999. He joined the Queen Mother Hospital as a Lecturer in Soft Tissue Surgery in October 2000 and became a Senior Lecturer in 2003. He was awarded his Professorship in 2007 and appointed as Head of Veterinary Clinical Sciences in August 2009.

Dan lectures in the respiratory and cardiovascular modules on the BVetMed undergraduate course as well as providing practical supervision and teaching to final year students and residents whilst on clinics. His is also a worldwide provider of CPD, lecturing at many institutions and conferences, including the BSAVA, WSAVA and the North American Veterinary Conference. He is the current President of the Association of Veterinary Soft Tissue Surgeons.

Dan is particularly interested in cardiothoracic and vascular surgery (especially management of portosystemic shunts), plastic and reconstructive surgery, surgical management of urinary incontinence, gastrointestinal surgery and surgery of the conducting airways.

David Connolly
BVetMed BSc PhD CertSAM CertVC DipECVIM-CA MRCVS

After qualifying from the Royal Veterinary College in 1988 David pursued a career in research with the Medical Research Council. Having obtained a PhD in molecular genetics, he continued research for three further years, investigating the molecular mechanism underlying early embryonic development. Following a period working for the PDSA in the Midlands, he returned to the RVC and completed a Residency in the Medicine Service. During this time, David obtained the RCVS Certificates in Small Animal Medicine and Cardiology, and subsequently the ECVIM Diploma in Cardiology in 2003.

David is head of the Cardiology Service at the Queen Mother Hospital for Animals (QMHA) and is a European Specialist in Veterinary Cardiology. His main research interest is novel interventional techniques for the treatment of cardiovascular disorders and the application of cardiac biomarkers to the clinical case.

Jane M Dobson
MA BVetMed DVMed DipECVIM-CA&Onc MRCVS

Jane graduated from the Royal Veterinary College, where she worked as houseman and registrar before studying comparative oncology at the Royal Marsden Hospital, London. In 1984, she moved to Cambridge as a research assistant working on
hyperthermia in the treatment of cancer, leading to the award of DVetMed in 1989. She received the BSAVA Woodrow award in 1994, and the Blaine award in 2001. Jane became a Diplomate of the European College of Veterinary Internal Medicine – Companion Animals in 1997, and received the BSAVA Blaine award in 2001. She is a founding Diplomate in the sub-speciality of Oncology in ECVIM and is a RCVS Recognized Specialist in Veterinary Oncology.

Jane is currently University Reader in Veterinary Oncology at the University of Cambridge. She is the co-author of Small Animal Oncology and co-editor of 2nd & 3rd edition of the BSAVA Manual of Canine and Feline Oncology. Her main interests are in anti-cancer chemotherapy, radiotherapy and research into breed associated tumours in dogs.

Victoria Doyle
BVetMed DVM DipECVN MRCVS

Victoria graduated from the Royal Veterinary College in 2004 and worked as a mixed practice veterinary surgeon in Kent for 1 year before returning to the Royal Veterinary College to complete a one-year rotating internship in small animal medicine and surgery. Victoria always had a strong interest in neurology and went on to complete a three-year ECVN approved scholarship in neurology at the Royal Veterinary College. Victoria passed the ECVN diploma in 2009 and is interested in all aspects of neurology but has a particular interest in inflammatory brain diseases.

Dr. Marco Ghionzoli
MD

Marco graduated as a (human!) doctor from the University of Firenze (Florence) in 2004. He took up training in Paediatric surgery first at the University of Pisa, returning to Florence in 2005. He worked at Great Ormond Street as a Senior House Officer, and since 2008 he has been an Honorary Research Fellow at the Institute of Child Health Surgery Unit based at UCL, London. He is presently completing a PhD looking into differentiation of amniotic fluid stem cells into smooth muscle lineage with electrophysiological analysis.

Michael E. Herrtage
MA BVSc DVSc DVR DVD DSAM MRCVS DipECVIM Dip ECVDI

Mike graduated from Liverpool University and is currently Professor of Small Animal Medicine at the University of Cambridge and a Fellow of St. Edmund's College, Cambridge. He is Dean of the Cambridge Veterinary School and is in charge of the small animal medicine and diagnostic imaging services at the Queen's Veterinary School Hospital. His clinical responsibilities include all aspects of small animal medicine and diagnostic imaging, but he has a particular interest in endocrine and metabolic disorders.

He was awarded the BSAVA Woodrow Award in 1986 and the Blaine Award in 2000. He has been President of the British Veterinary Radiology Association, President of the British Small Animal Veterinary Association, President of the European Society of Veterinary Internal Medicine and President of the European Board of Veterinary Specialisation. He is a Diplomate of both the European College of Veterinary Medicine.
Internal Medicine and of the European College of Veterinary Diagnostic Imaging and was recently President of the European College of Veterinary Internal Medicine. Mike has spoken at many international meetings and published over 200 articles in refereed journals.

Peter Holt
BVMS PhD DECVS CBiol FIBiol FHEA FRCVS

Peter graduated from Glasgow University in 1970. After a year as House Surgeon there, he spent two years lecturing in small animal clinical studies in Nairobi, Kenya. A further seven years was spent in general practice before his appointment as lecturer at the University of Bristol where he was Professor of Veterinary Surgery until his retirement in 2009 when he was made Emeritus Professor. His interests include aspects of soft tissue surgery, especially of the urinary system. He is author of, or contributor to, over 140 refereed papers and book chapters and has received six awards for his clinical and research activities. He has published two books on veterinary urology. He is a Past-President of the European Society of Veterinary Nephrology and Urology and in 1991 was awarded the Fellowship of the Royal College of Veterinary Surgeons for meritorious contributions to learning in the field of Veterinary Urology. He is currently Emeritus Professor at the University of Bristol.

Karla Lee
MA VetMB PhD CertSAS DipECVS MRCVS

Karla Lee graduated as a vet from the University of Cambridge in 1998. Immediately after graduation, she flew out to Philadelphia to complete an internship in small animal medicine and surgery at the University of Pennsylvania. She returned to the UK in 1999 and won a Wellcome Trust Veterinary Prize Studentship to conduct a PhD, in which she investigated the role of the oestrogen receptor in the development of post-menopausal osteoporosis in women.

In 2003, Karla began a residency in small animal surgery at the Royal Veterinary College, becoming a Diplomate of the European College of Veterinary Surgeons in 2007. She has been a Lecturer in Small Animal Surgery at the Royal Veterinary College since 2008.

Karla has conducted research in the areas of bone physiology and small animal surgery including congenital canine portosystemic shunts and canine ureteric ectopia. Her current research interests include the effect of attenuation of congenital portosystemic shunts in dogs, portal hypertension and liver failure.

Jane Ladlow
MA VetMB, Cert VR DipECVS MRCVS

Jane graduated from the University of Cambridge in 1995 and then completed an internship at the University of Bristol followed by a year in general practice. A residency at the Royal Veterinary College, London followed and Jane became an ECVS Diplomate in 2002. After 4 years at the Animal Health Trust she moved to the University of Cambridge where she is currently a Lecturer in Soft Tissue Surgery. Jane has a particular interest in oncological surgery.
Vicky Lipscomb  
MA VetMB CertSAS DipECVS FHEA MRCVS

Vicky graduated from Cambridge University in 1996 and has spent time in both general and specialist referral practice. Vicky undertook her post-graduate surgical training at the Royal Veterinary College and returned there as a Lecturer in Small Animal Surgery in 2003. She is a European Specialist in Small Animal Surgery. Vicky is interested in all aspects of soft tissue surgery and current clinical research interests include congenital portosystemic shunts in dogs and cats.

Siobhan Mullan  
BVMS PhD DWEL MRCVS

Following graduation from Glasgow in 1997 Siobhan Mullan worked in mixed practice before joining the University of Bristol small animal practice in 1999. After four years there she gradually spent less time in practice and more time conducting research into the welfare of pet rabbits and dogs and evaluating frameworks for veterinary ethical decision-making, focussing on the role of autonomy. She gained the RCVS Diploma in Animal Welfare Science, Ethics and Law in 2006 and completed a very political PhD on the inclusion of welfare measures into the UK pig farm assurance schemes in 2009. Her current research interests include the welfare of pet rabbits, the welfare of UK horses, particularly tethered horses and improving farm animal welfare through farm assurance but she maintains a wide interest in bioethical issues and has co-ordinated the ‘Everyday Ethics’ series in In Practice for 4 years (contributions/ scenarios always welcome!).

Gerhard Oechtering  
Prof. DrMedVet DipECVAA

Gerhard graduated from the Berlin Free University, where he remained after graduation whilst studying for a Doctoral degree in. He then moved to a position in the Anaesthesia and Intensive Care department of Justus Liebig University Veterinary School, Giessen. In 1994, he joined Leipzig University as Professor of Small Animal Diseases and Head of Small Animal Medicine, where he remains to this day. Gerhard is a Diplomate of the European College of Veterinary Anaesthesia and Analgesia and founded the Brachycephaly Study Group at Leipzig. He is interested in all aspects of ENT surgery.

David Sargan  
MA PhD

Dr David Sargan is a comparative geneticist, educated in Cambridge and at University College London (PhD in Molecular Biology). Following postdoctoral positions in the University of Geneva and in Baylor College of Medicine, Houston Tx, Dr Sargan entered the veterinary world as a Lecturer at the R(D)SVS, Edinburgh. It was during this period that Dr Sargan started to work in canine genetics, initially looking at Progressive Retinal Atrophy. Since moving to Cambridge University Veterinary School (1994), Dr Sargan has concentrated initially on the canine genome map, and
subsequently on mutation finding largely in canine eye diseases and latterly in cancer and some other areas. Dr Sargan curates the database Inherited Diseases in Dogs. His other major interest is in research students development. He directs the Graduate School of Life Sciences (which covers graduate students working in Veterinary, Medical and Biological Sciences) for Cambridge.

Tobias Schwarz
MA DrMedVet DVR DipECVDI DACVR MRCVS

Tobias graduated in Veterinary Medicine from the Free University of Berlin in 1995, where he then undertook a Doctoral degree, which he completed in 1997. He then moved to Glasgow for a BSAVA Petsavers’ Residency in Diagnostic Imaging, gaining the Diplomas of both the Royal College of Veterinary Surgeons (Veterinary Radiology) and the European College of Veterinary Diagnostic Imaging in 2000.

Tobias has served as an Assistant Professor at the Universities of Pennsylvania and Wisconsin-Madison. In 2009 moved to the Royal (Dick) School of Veterinary Studies (University of Edinburgh) as Senior Lecturer in Diagnostic Imaging. He has written several papers and textbook chapters, and has clinical interests in Computed Tomography, Neuroradiology and Airway Imaging.

Mickey Tivers
BVSc CertSAS DipECVS MRCVS

Mickey Tivers graduated from Bristol in 2002. He completed an internship at the Royal Veterinary College (RVC) followed by a year in small animal practice and a surgical internship at Bristol. This was followed by a residency in small animal surgery at the RVC, which he finished in 2008. He is currently enjoying a PhD studying portosystemic shunts in dogs. He is a Diplomate of the European College of Veterinary Surgeons and he is a European and RCVS specialist in small animal surgery.

Chick Weisse
BA VMD DACVS DACVR

Chick graduated from the University of Pennsylvania in 1998, where he then undertook an internship and subsequent residency in small animal surgery, achieving Diplomate status from the American College of Veterinary Surgeons in 2003. In 2002, Chick became a lecturer in surgery at the University of Pennsylvania School of Veterinary Medicine, and was Director of the Interventional Radiology Service there from 2002-2009. He was an Assistant Professor in both Surgery and Radiology from 2007-2009.

Chick has contributed regularly to veterinary literature and is an extremely well known international keynote speaker. He is now a Staff Surgeon at the Animal Medical Centre in New York, where he is also Director of the Interventional Radiology Service.
Robert White  
BSc (Hons) BVetMed CertVA DSAS (Soft Tissue) DipECVS MRCVS  

Rob graduated from the Royal Veterinary College in 1989. He holds the RCVS Diploma in Small Animal Surgery (Soft Tissue) and is a Diplomate of the ECVS. He is a RCVS and European Specialist in Small Animal Surgery. In 2002 he was awarded the BSAVA Simon Award for outstanding contributions to veterinary surgery. He is a Special Professor of Small Animal Soft Tissue Surgery at Nottingham University. He co-established Davies White Veterinary Specialists in 1998. He then established his own Surgical Consultancy Service in 2004 providing his surgical services on a peripatetic basis to general practices, referral centres and universities throughout the UK.

In August of 2009 Rob joined Willows Veterinary Centre and Referral Service to help establish a new soft tissue surgery service in their brand new state-of-the art premises in Solihull, United Kingdom.
Inherited and congenital genetic disease: How much of a problem?

Congenital disease: the human situation.

Disease which is present at birth is not invariably inherited, but can occur through the same set of different causes (genetic, environmental, infectious) as disease at any other stage of life. Both environmental (nutritional and intrauterine) and infectious disease are hugely important – but today I am concentrating on congenital (as well as later onset) genetic disease. Around 6% of all conceptions have chromosome anomalies, but most of these lead to resorption of the embryo, or to stillbirths. Worldwide today, about 5% of human children are born with a congenital or hereditary disorder and almost 40% of adults are treated for common diseases with large inherited components during their lifetime. In developed countries, congenital and genetic disorders account for at least a quarter of deaths under the age of four years (WHO, 1999; Emory and Rimion, 2002). In addition to the associated morbidity, the health care costs of genetic diseases are huge. For example, between 30 and 40% of children’s hospital beds in the UK are occupied by sufferers of inherited or congenital disorders (Polani, 1988). Individuals with diabetes mellitus in the USA have between 2 and 3 times the health care costs of others of similar age. This disease alone, (with 177 million sufferers worldwide, and roughly 30% heritability), accounts for 8% of total health budgets in industrialised countries (WHO, 2002).

Global figures for veterinary species are less easy to come by, but it seems likely that at least in companion animals in the UK, inherited disease is at least as important as it is in humans. In most of this talk I will concentrate on dogs, but I will occasionally refer to other species.

Congenital genetic disease in dogs.

The burden of genetic disease begins before birth. Reproductive defects and embryonic and early foetal mortality are recognized by reductions in litter size. There is a strong correlation between average litter size and body weight across most breeds, but some (Pomeranian, Cavalier King Charles Spaniel, Newfoundland) throw unexpectedly small litters. There are few recent studies of heritability of perinatal mortality in dogs. Older studies have found modest effects of sire on litter size (Lyngset, 1973, Gaines and Van Vleck, 1976). Estimates of the total burden of congenital defects include a mortality estimate of 6.3% (Walter and Kirchhoff 1995) and an estimated prevalence of congenital defects of 16.5% in puppies offered for sale (Ruble and Hird, 1993). Estimates of the total burden of congenital defects include a mortality estimate of 6.3% (Walter and Kirchhoff 1995) and
an estimated prevalence of congenital defects of 16.5% in puppies offered for sale (Ruble and Hird, 1993). The prevalence of a number of congenital abnormalities has been estimated in case series. As would be expected, there are breed specific prevalences of many defects, suggesting that some congenital disease is inherited. A study of sub-aortic stenosis (SAS) found that breeds at significantly increased relative risk included the Newfoundland, with a breed incidence of >10% (odds ratio, 88.1), Rottweiler (odds ratio, 19.3), Boxer (odds ratio, 8.6), and so on (Kienle et al., 1994). Of the dogs available for follow-up, mortality attributed to SAS was 21%.

**Diseases shown to be inherited**

Dogs have a larger number of recorded naturally occurring inherited diseases than any other species apart from man. Estimates of total numbers of genetically independent diseases vary greatly, but at 489 different disease phenotypes (phenes) have been recorded (OMIA, Nicholas 2009) and 1353 combinations of phene with breed (IDID, Sargan 2004, 2009).

**Selection for inherited disorders**

The large number of inherited disorders and diseases suffered by pedigree dogs is well documented and has become a cause of emotional and divisive argument amongst those with an interest in dogs in the UK, the USA and elsewhere. However, apart from these old studies of congenital disease, there has been relatively less attempt to provide a dispassionate overview of the extent of the genetic health problem for such dogs. There is a paucity of good statistical data with which to measure and quantify this problem. Nevertheless, it is possible to identify two separate sources for health and welfare problems in the purebred and pedigree dog: selection for excessive or exaggerated physical, conformational or specific cosmetic features; and inbreeding. Selection for extreme traits in anatomy is causing easily measured effects on mortality and severe effects on morbidity to a number of breeds that are currently increasing in popularity in many countries. The genetic causes of such traits are driven to high frequencies (often to fixation) within breeds by selection for traits seen as desirable in the show ring. Where selective capacity still exists (as in size for giant breeds) extremes are becoming more profound.

For example brachycephalic breeds on average have a life expectancy 2.3 years below breeds of similar size but more normal skull shape. Furthermore disorders resulting from selection for specific conformation or other cosmetic traits are common and cause morbidity effects in substantial numbers of individuals in about half of all pedigree breeds. However, it is very difficult to obtain morbidity comparisons with cross-bred animals. In the UK, against a background rise in total pedigree dog registrations of 5% over the ten-year period 1998-2007, Kennel Club registrations of severely brachycephalic breeds have more than doubled in 1998-2007: 14987 to 31100 registrations.
Many genetic disorders manifest in all or a high proportion of individuals as a clear consequence of the related cosmetic trait. But even in instances where the disorder is only a less direct consequence of the selected trait, prevalence may still be considerable. For instance deafness in spotted and merle dogs depends on the partial and apparently quasi-random distribution of melanocytes. Yet surveys of deafness in Dalmatian dogs and in merles show strikingly high prevalence of deafness, often above 20% (Wood and Lakhani 1997; Famula et al., 2001; Muhle et al., 2002; Cargill et al., 2004, Strain et al., 2009).

It should also be recognised that some common inherited traits are probably not under direct selection, but are either closely linked to something that is or have been associated with a breed because they were present in the breed founders. Thus a mutation in an ion transporter SLC2A9 causes gout in all Dalmatians – but is unlikely to be under selection itself.

**Inbreeding**

For any recessively inherited defect inbreeding is expected to increase the disease load at a given gene frequency, and it is commonly suggested that the emergence of large numbers of genetic diseases in many breeds of dog is because of inbreeding. Even though numerous breeds in the UK have effective population sizes, only around 1% of the numbers of dogs are registered. Inbreeding also causes losses of rare alleles from a population including disadvantageous ones. The increase in disease frequency caused by inbreeding could be around 1.5 to 2 fold in many breeds in monogenic disorders, although the effect is much less striking for polygenic disorders.

**Genetic mapping and DNA based tests**

The power of genetic mapping in finding mutations is increasing rapidly. I will
briefly review the whole genome array based mapping technology and what it offers. DNA based tests do offer a new power to remove mutations from populations, and even for polygenic disease the removal of just one of the disadvantageous genes can be shown to be very helpful in the control of disease. It is very important in using these tests, that the tester advises the owner and the breed club properly. Note that by reducing genetic diversity further, genetic tests may aggravate problems with inbreeding or increase prevalence of other diseases.

For this reason some recent emphasis has been placed by the Kennel Club on the development of estimated breeding values – these are a means of looking at multiple factors at once. They are very useful in advising breeders and in removing diseases quickly. But they are not a panacea. If a breed has a mutation in all individuals, then the only way to get rid of it is to breed out: to introduce individuals from another breed. This will be illustrated by looking again at the Dalmatian.

References
The Ethics of the Management of Diseases Present at Birth: Individuals versus Populations

Dr. Siobhan Mullan

Introduction

The management of a patient with a disease present at birth is necessarily focussed on the individual needs of the animal. Where the condition is congenital, and without a heritable component, the most appropriate management can be determined in the usual clinical way. Although there are other ways of approaching this it will likely involve the exploration of the possible options with the owner, and weighing up the expected costs and benefits (those familiar items such as animal welfare, monetary cost and so on) of each option to the animal and other stakeholders. Where the congenital condition has a heritable component (regardless of whether it arose by deliberate breeding or random genetic mutation) the analysis may be complicated by a consideration for the potential welfare of any offspring of the animal. It is this issue, in particular when animals are deliberately bred with traits that reduce welfare or increase the risk of poor welfare, that will be discussed in more depth here.

Background, from an ethical perspective

For a significant period of time it has been recognised that certain breeds or types of animal (such as colour morphs) were at a higher risk of specific disease conditions, either directly, or indirectly as a result of breeding for particular traits. Certainly it was reported academically, understood by veterinary surgeons and some breeders and owners, and had been considered by CAWC\(^1\). However, it appears either not to have been widely known about, or given sufficient weight to, by the general public until the effects on dogs were exposed on television in August 2008\(^2\). Of course, since then we've had three major reports (by the RSPCA\(^3\), Associate Parliamentary Group for Animal Welfare\(^4\) and Prof. Bateson\(^5\)) and are on the cusp of an independent Advisory Council on Welfare Issues on Dog Breeding. The questions that I'm interested in about this journey relate to the ethical stance of vets and others.

Contrary to some of the chunterings I have heard and the obvious financial incentives, in my experience vets are disappointed to see breed-related problems in their patients and usually discuss this with owners. When potentially useful, they may encourage neutering along with treatment to prevent repeat problems in future generations. As an undergraduate insistence on neutering was taught to us as ‘best practice’, however, this has been challenged by some vets on the grounds of paternalism and a more relationship-based ethical approach could involve a discussion with the owner, but ultimately leaving the decision of whether to breed from an affected animal with them.

Given that welfare problems associated with breeds of dog have increased as appearances have become more extreme\(^3\) we can reflect on whether we took the right courses of actions for our patients. Did we do enough, both
individually and collectively as a profession, to prevent suffering of future populations? Or perhaps we just had to wait until there was a change in the perception of society about what was acceptable for pet animal breeding - I wonder whether the television programme would have had the same impact 10 or 20 years previously.

The big picture - do breeds matter?

The CAWC report of a workshop held in October 2008 'Approaches to tackling genetic welfare problems in companion animals' usefully highlights some of the ethical issues surrounding breed-related problems. They point out that fundamental to determining our actions in this issue is our view on the importance of breeds per se. If we believe that having breeds has intrinsic value - i.e. a value in itself, then we should aim our actions at promoting that value by retaining breeds wherever possible. It may at first sight seem odd that a non-sentient thing - breeds (rather than individuals within breeds) - may have intrinsic value but there are parallels with environmental ethics where species or ecosystems may be regarded as having intrinsic value. In this case, improving the welfare of the individuals within the breeds is still important and can be achieved through genetic selection, providing the breeds still retain their important characteristics.

If, on the other hand, we believe that breeds have only an extrinsic value - i.e. a value to us through, for example, being aesthetically pleasing or functionally appropriate to our needs, then there is a more complex analysis to be undertaken. As there is no obligation to preserve breeds it may be that some, or all breeds, could be allowed to disappear. This would depend on how their importance to us is balanced against any welfare consequences to the animals.

Individuals versus Future Individuals

There are many instances in veterinary surgery where our actions for one individual patient may increase the risk of poor welfare for future patients or generations of animals - just think of indiscriminate antibiotic usage. In the case of heritable risk factors for poor welfare, there are other responsible parties in the form of breeders; but as we may have some influence in this area we need to consider whether we have any obligations to future generations. Could we simply say that we do all we can for our individual patients and leave it at that? Certainly not all ethical approaches require us to consider the possible consequences of our actions. Therefore, it could be argued that if we are acting in accordance with a rule (deontology) or acting ‘virtuously’ (virtue ethics) we do not need to consider the effect on future generations. However, it can be difficult to act virtuously or follow such rules in the grey area of veterinary practice and we usually resort to weighing up the pro’s and con’s of an action, where considering the consequences of our actions is an important feature of this ethical approach (utilitarianism). It seems a commonly held view that in general terms at least some consideration should be given to future generations - this is the impetus behind considerations to reduce the effects of climate change, for example. But
how much weight should they have on the scales? It would seem impossible to try and account for all future individuals so perhaps we should only go as far as can be reasonably predicted - the next generation, certainly. Such is the beauty of sexual reproduction that (apart from a few specific conditions) the passing on of welfare problems will occur in a slightly unpredictable way for each offspring, producing variety amongst litter-mates and therefore variation in risk of poor welfare. This makes it a bit more difficult to analyse but it’s always important to try to estimate the consequences of our actions accurately. This is something that research can help us improve, for example by better understanding of the heritability of genetic traits.

**What should be done in practice?**

A dilemma only arises when there is a conflict between the welfare of an individual animal and either a) the future welfare of other individual animals or b) other interests of associated parties such as breeders. If we accept that certain ‘welfare risky’ breeds can continue to exist then even if we implement a strong programme to minimise the welfare problems in the future, in the interim period there will inevitably be animals bred with consequent poor welfare. So, in practice, when faced with ‘fixing’ an animal of breeding age, with a significant condition that has heritable risk factors there are several options available:

<table>
<thead>
<tr>
<th>Primary options (relating to the individual patient)</th>
<th>Secondary options (relating to future individuals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>Investigations into parental lines/ sibling welfare</td>
</tr>
<tr>
<td>Treatment + neutering</td>
<td>Reporting to central surveillance</td>
</tr>
<tr>
<td>Euthanasia</td>
<td>Discussions with the breeder</td>
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<td></td>
<td>Whistle-blowing ‘bad’ breeders</td>
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<td></td>
<td>Wider dissemination of information- e.g. to the media</td>
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The primary options need to be considered using one’s ethical viewpoints on the intrinsic nature of breeds and our responsibility to future generations, as well as other factors. A decision tree for working through these options is shown in Figure 1. Once the ethical pathway that aligns with our personal values is chosen one critical decision point might be whether there is a ‘high chance of poor welfare of the offspring’. Both ‘high chance’ and ‘poor welfare’ are undefined, but genetic advice and appropriate welfare assessment will help to guide this decision.

The secondary options may be explored in some cases when it is suspected further actions would help to prevent welfare suffering of animals in the next generation. This will undoubtedly take time for no financial reward but I wonder whether, if more of us had taken some of these actions when we were uncomfortable with a clear welfare problem, we might have been a good deal further down the road to welfare improvement.
Do breeds have an intrinsic value?

Is there an obligation to the welfare of future generations?

Are there small numbers in the breed?

Is the animal required for breeding to maintain the breed? (seek genetic advice)

Do you think, against advice, the owner will allow the animal to be bred from?

Do the benefits of that breed to society (extrinsic value) outweigh the likely poor welfare to the individual offspring?

Is there a high chance of poor welfare of the offspring? (seek genetic advice)

Are there small numbers in the breed?

Treatment, except when extremely poor welfare / chance of recovery, when euthanasia is preferable

Treatment or euthanasia (normal clinical decision for that animal)

Treatment or euthanasia (normal clinical decision for that animal)

Treatment + neutering or euthanasia

Treatment, except when extremely poor welfare/ chance of recovery, when euthanasia is preferable

Treatment + neutering or euthanasia

Treatment + neutering or euthanasia

Treatment or euthanasia (normal clinical decision for that animal)

Do you think that, against advice, the owner will allow the animal to be bred from?

Do you think that, against advice, the owner will allow the animal to be bred from?

Figure 1: decision tree for primary options in clinical cases of heritable conditions in animals of breeding age
References
2 Pedigree Dogs Exposed. BBC Television Programme broadcast 19/8/2008
The Way Forward?

Dr. Michael Herrtage

The spotlight was placed on dog breeding with the showing of a television documentary called *Pedigree Dogs Exposed*. It was a hard-hitting piece of journalism which was directed at those breeders of pedigree dogs who ignored the adverse effects of inbreeding and particularly those who were breeding for extreme conformations. The programme led to a number of inquiries into pedigree dogs and dog breeding. A few of their recommendations will be considered in respect of the way forward, but none offers an easy ‘fix’.

Addressing the inadequacies in the way dogs are bought and sold

The situation regarding puppy farming has been known about for years and has been actively encouraged in certain parts of the British Isles as part of a diversification scheme for farmers. The mass breeding of puppies ‘to order’ in order to comply with fashion is a profitable business. Despite the failure of existing schemes, a public awareness and education campaign designed by experts should be developed in order to persuade members of the general dog-buying public to change their behaviour and to provide readily comprehensive information on what questions to ask and what to look for when buying a dog.

When a robust and audited Accredited Breeders Scheme is available, the buying public should be directed with confidence towards members of the scheme as offering a genuinely higher standard of health and welfare to the animals in their care.

Addressing poor and negligent management in the care of breeding dogs

There is a definite need to be regulate breeding more effectively than at present. Local Authorities should address all welfare issues covered by the Animal Welfare Act 2006, especially those relating to dog behaviour.

The Bateson Inquiry suggested that:

i) All breeders should have their puppies microchipped before they are sold and prospective purchasers should expect this to be done before buying a puppy.

ii) Regulations should be made under the Animal Welfare Act 2006 to create an obligation on any person breeding dogs to have regard to the health of both parents and the offspring.

iii) Any body laying down breed standards must have regard to the
health and welfare of dogs and the need to avoid specific health problems.

To enforce the latter, DEFRA should implement a statutory Code of Practice on the Breeding of Dogs under Section 14 of the Act.

**Addressing inbreeding, inherited disease and selection for extreme morphologies**

A non-statutory Advisory Council on Dog Breeding is being established under the chair of Professor Sheila Crispin. Its key role will be to develop evidence based breeding strategies that address the issues of poor conformation, inherited disease and inbreeding as appropriate to the specific breeds and to provide advice on priorities for research and development in these areas.

High priority needs to be given to the creation of a computer-based system for the collection of anonymised diagnoses from veterinary surgeries in order to provide statistically significant prevalence data for each breed. This should build upon the work already started by the Royal College of Veterinary Surgeons.

Revisions to the Breed Standards should recognise the need to avoid the selection for extreme morphologies that can damage health and welfare of the dog. These new Breed Standards should be enforced by close monitoring and training of Dog Show Judges.

The minimum conditions for an Accredited Breeder Scheme should be that:

i) All pre-mating tests for inherited disease appropriate to the breed are undertaken on both parents.

ii) No mating takes place if the tests indicate that it would be inadvisable in the context of welfare or breeding strategy.

iii) Any prospective purchaser is able to view the puppies with their mother.

iv) Every puppy is permanently identified.

v) Clear, written standards of management with regard to housing, health, exercise and socialising of all dogs are established.

vi) All relevant documentation connected with the puppy including registration documents, are handed over to the purchaser at the time of sale.

vii) All assured breeders are inspected against a written standard

viii) No compliance results in de-registration.

Clearly there is still a lot to be done, but many groups and individuals have been active and improvements have been noted. The downside is that the schemes are voluntary and there is little regulation, so that unscrupulous breeders can still continue to breed indiscriminately.
Brachycephalic Airway Obstructing Syndrome: Some Further Controversies

Prof. Robert White

The brachycephalic airway obstructing syndrome (BAOS) is a group of congenital and acquired abnormalities of the upper airway that results in signs of upper airway obstruction. There are a number of well-described congenital abnormalities that are associated with the condition. These include,

- stenotic external nasal apertures
- shortening, widening, and flattening of the nasal cavity and pharynx
- relative over-size of the tongue
- relative elongation, thickening, and flaccidity of the soft palate
- decreased glottic size
- hypoplasia of the trachea.

There are also a number of well-recognised acquired abnormalities that develop as a result of the chronically increased inspiratory effort and associated negative airway pressures. These include,

- oedema and further thickening of the soft palate
- eversion of the laryngeal saccules/ventricles
- oedema of the pharyngeal and laryngeal mucosa
- enlargement of the tonsils
- progressive laryngeal dysfunction ending in complete laryngeal collapse.

In addition to these abnormalities there are a number of less well-known and/or controversial findings that warrant further consideration.

1) Concurrent sliding hiatal hernia

The presence of concurrent sliding hiatal hernia is dog’s suffering from BAOS has been described previously. Hardie and others’ (1998) performed a case-control study of bulldogs by searching their veterinary medical database at Purdue University for bulldogs presenting with the condition “hiatal hernia”. For each of the 23 bulldogs found presenting with hiatal hernia, four control bulldogs were selected, resulting in a total of 115 dogs. Their findings showed that bulldogs with hiatal hernia were more likely to have at least one diagnosis associated with brachycephalic syndrome than were bulldogs without hiatal hernia. They concluded that hiatal hernia was associated with the more severe manifestations of brachycephalic syndrome.

Assessing the true incidence of hiatal hernia in brachycephalic dogs is less than straightforward. The incidence of clinical signs consistent with a hiatal hernia (ptyalism, regurgitation/vomiting - especially of frothy material, unexplained periods of dullness, lethargy and anorexia, etc.) in
brachycephalic dogs is high. Personal observations in approximately 100 cases would indicate that at least 70% of bulldogs have a clinical history consistent with a hiatal hernia. This high prevalence of gastrointestinal clinical signs is supported by the findings of Poncet and others (2005). Their retrospective study of 73 brachycephalic dogs with upper respiratory disease showed that 74% of the dogs presented for respiratory problems had weekly, daily or more frequent episodes of ptyalism, regurgitation and/or vomiting. Interestingly, they only confirmed a diagnosis of axial hiatal hernia in 3/73 dogs (4.1%) although oesophageal deviation was found in 12/73 dogs (16.4%) and gastro-oesophageal reflux in 23/73 of dogs (31.5%).

Unless the axial hiatal hernia is trapped in the thoracic cavity, making a definitive diagnosis of axial/sliding hiatal hernia requires observation of the movement of the lower oesophageal sphincter and local gastric fundus into the caudal thoracic cavity (usually assessed by performing a contrast feeding study with fluoroscopy). Unfortunately, in many instances (lack of fluoroscopic facilities, uncooperative patient, etc.) such studies fail to diagnose the condition.

In many instances, the clinical signs of ptyalism, regurgitation and vomiting are significantly reduced following the surgical management of the BAOS (Poncet and others 2006). A further improvement of clinical signs can be achieved by the provision of medical management for reflux oesophagitis and hiatal herniation (gastric protectants, antacids, prokinetics agents, altered feeding regimes, etc.). Personal observations suggest that significant clinical signs consistent with a hiatal hernia are observed in up to 20-30% of bulldogs following surgical treatment for BAOS. In these individuals surgical intervention will almost invariably confirm the presence of a sliding hiatal hernia requiring surgical repair.

2) The “odd” breeds

There are a number of breeds in which some individuals show signs consistent with BAOS even though the breeds themselves are not brachycephalic. Examples include the Yorkshire terrier, the Norfolk terrier and the Norwich terrier. Affected individuals rarely show the nasal aspects of the disease recognised in the true brachycephalic breeds. Rather, these breeds present with a range of issues mostly associated with their caudal nasopharynx, pharynx and larynx. Their clinical signs may be similar to those of true brachycephalic breeds but by taking a careful history and performing a thorough examination the problem can often be localised to the nasopharynx (reverse sneezing and intermittent stertor) or the larynx (intermittent or persistent stridor). In some instances, affected individuals do appear to have overlengthening of their soft palates. In others, the palate appears completely normal or even shorter than normal. In either case, the palate is rarely thickened as one would expect in the true brachycephalic dog. In many instances, the clinical sign is predominantly one of stridor. Not surprisingly, in
such cases the problem is often localised to the larynx. Findings can be surprisingly variable and include apparent laryngeal paralysis, laryngeal cartilage dysplasia, solitary eversion of the laryngeal saccules, failure of arytenoid cartilage abduction/adduction with apparent fixation of the arytenoid cartilages (ankylosis), laryngeal cysts, laryngitis, laryngeal oedema, etc. It can prove very difficult to make a confirmed diagnosis in these cases and without a diagnosis it can also prove difficult to provide an effective management.

The Cavalier King Charles spaniel also warrants further discussion. Previous reports from the UK and Australia would suggest that this breed is commonly presented for the investigation and management of BAOS (Lorinson and others 1997, Torrez and Hunt 2006) in both these countries. Surprisingly, a recent retrospective series of 62 dogs from North America (Riecks and others 2007) contained no individuals of the breed. Like the three breeds discussed above, it is my experience that the Cavalier King Charles spaniel presented for the further investigation of ‘BAOS’ commonly does not have the classic findings seen in the bulldog, French bulldog, Pekinese, Pug, etc. Their nasopharyngeal obstruction is often characterised by a subjectively narrow (smaller than expected for a breed of their size) nasopharyngeal space and it is quite common that they do not show evidence of overlength of the soft palate. Interestingly, a recent report (Hayes and others 2010) confirmed a significant association between the presence of otitis media with effusion (on MRI) and an increase thickness of the soft palate and reduced nasopharyngeal aperture. Many of the cases show evidence of otitis media with effusion (OME) on either otoscopic examination or other imaging studies of the tympanic bullae. Malformation of the nasopharynx and soft palate is recognised to be associated with the formation of otitis media with effusion in the dog (White and others 2009). The prevalence of caudal fossa (cranio cervical junction abnormalities including occipital hypoplasia) malformations is high in the Cavalier King Charles spaniel and is considered to be associated with the presence of neurological signs observed in individuals suffering from cerebellar herniation and syringohydromyelia (Cerda-Gonzalez and others 2009). It would seem reasonable to hypothesise that the Cavalier King Charles spaniel might suffer from a syndrome of conditions (syringomyelia, OME, nasopharyngeal airway obstruction, etc.) that are all associated with the malformation of the caudal aspect of the skull.

3) Nasopharyngeal turbinates

A recent study (Ginn and others 2008) identified the presence of nasopharyngeal turbinates in 21% (53 brachycephalic dogs and 10 brachycephalic cats) of brachycephalic animals examined, including 21% and 20% of cats. Pugs accounted for 32% of all dogs in the study population and 82% of dogs with nasopharyngeal turbinates. The nasal cavity should be considered the primary location for the development of airway obstruction in brachycephalic dogs and cats (Oechtering and others 2010). Abnormal conchal growth leading to obstruction of the nasal meatus will cause severe intranasal obstruction and increased intranasal airflow resistance in the majority of dogs with brachycephalic syndrome. A DIODE-Laser can be used
to remove the obstructive parts of the conchae thus creating a new meatus nasi ventralis. In a prospective study of 80 brachycephalic dogs the use of laser assisted turbinectomy (LATE) produced a reduction in intranasal airflow resistance of approximately 50% (Oechtering and others 2010).

4) **Dorsal collapse of the pharynx**

Dorsal collapse of the pharyngeal wall is recognised but unreported finding and cause for airway obstruction in brachycephalic dogs. Diagnosis of the condition requires lateral fluoroscopic examination of the pharynx/larynx in the conscious dog. In cases where this condition is assessed it appears to be a potential significant problem. There is, at present, no specific surgical management for the condition. The response of the condition following the more standard surgical interventions for BAOS also remains unclear.

5) **Glosso-epiglottic fold**

Displacement of the glosso-epiglottic mucosa (sub-epiglottic fold) was first described in 1983 (Bedford 1983). Partial but extensive obstruction of the aditus laryngis and rostral rima glottidis by displaced folds of the glosso-epiglottic mucosa can occur in brachycephalic dogs during inspiration. The diagnosis of the condition remains both difficult and controversial; in some individuals the displacement of the mucosa can be observed directly observed whilst the animal is lightly anaesthetised. It others movement of the soft tissues at the base of the tongue during fluoroscopic examination of the pharynx/larynx in the conscious dog may be assessed as displacement or sucking of the glosso-epiglottic fold into aditus laryngis. The displacement is transient, the tissue returning to its sub-epiglottic position on expiration. In the dog, actual entrapment of the epiglottis is not seen as a consequence of the displacement. In selected cases the condition may be managed by the sharp excision of the glosso-epiglottic mucosal fold. Complicating post-operative sub-epiglottic adhesions or granulation have not been observed. The surgery may be associated with an increased pharyngeal discomfort and possible increased risk of regurgitation with its associated risk of life-threatening pharyngeal/laryngeal oedema formation.

6) **Excision of the tonsils as part of the surgical management of BAOS**

The routine or selective excision of enlarged tonsils as part of the surgical management of BAOS remains controversial.

7) **Excision of the everted laryngeal saccules as part of the surgical management of BAOS**

Some controversy remains regarding the necessity for routine excision of everted laryngeal saccules in brachycephalic dogs suffering from stage I laryngeal collapse. In the author’s opinion, the presence of everted
laryngeal saccules represents a significant cause of airway obstruction in affected individuals. Their resection is relatively straightforward and in most instances, their removal results in a dramatic and immediate enlargement of the rima glottidis. When performed appropriately their excision does not appear to be related to any short or long term complications. On the contrary, inappropriate and/or inadequate excision could possible result in the formation of ventral laryngeal webbing.

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Introduction
The Brachycephalic Airway Obstructing Syndrome (BAOS) is a well-described combination of upper airway disorders in certain dog and cat breeds. Veterinarians should be aware, that it is a man-made hereditary disease, caused by exaggerated and incorrect breeding selections. This has led to fateful overemphasis of brachycephalia. The result is an almost complete loss of the nose, additional malformation of pharynx and larynx, and several other serious handicaps. Affected animals suffer from lifelong respiratory distress, particularly during elevated ambient temperatures – and most owners suffer with their pets.

Reports on breathing difficulty in short-nosed breeds of dogs and therapeutic suggestions date as far back as the 1930s. Symptoms can vary broadly in intensity, as can frequency of dyspnoeic episodes. Snoring is the most common manifestation. In the worst cases, severe dyspnoea with life-threatening asphyxia and syncope may be seen. Most authors focus on the same specific anatomic features when characterising BAOS so as to explain reasons for the respiratory problems: narrow nostrils, elongated soft palate and everted laryngeal ventricles. However, excessive selection for expression of brachycephalia has changed and deformed the entire upper respiratory tract. New studies have shown that airway distress is caused by far more numerous constrictions in the upper airways than was previously thought.

Common Therapeutic Approach
Present surgical therapeutic recommendations in BAOS are well known and include widening of stenotic nares, shortening of an elongated soft palate and, if required, resection of everted laryngeal saccules. This triad has remained substantially unchanged for a long time. This is to some extent surprising; there are several indications that the common therapeutic approach fails to provide lasting improvement, although the discussion on evidence is controversial. In the past, pathophysiologic assumptions and subsequent therapeutic considerations probably concentrated too much on structures being easily visible and accessible, like the nares, the soft palate and the so-called laryngeal saccules. However, the striking difference between a "normal" and a brachycephalic dog is the "missing nose". We regard the nasal cavity as the primary location where many brachycephalic airway problems predominantly arise and this is the site, where our diagnostic and therapeutic efforts started.

NEW Therapeutic Approach: ADDITIONAL Levels and Modalities
Grossly exaggerated breeding for brachycephalic features during recent decades generated a "new" generation of “extreme brachycephalic” animals. In these, the common therapeutic techniques, which had been considered successful for many
years, have proven far more prone to failure.

Obstruction at the Nasal Entrance: Vestibuloplasty

It is well known that stenotic nares are recognisable with the naked eye: the alae nasi are extraordinarily enlarged, giving the nares the appearance of a “head down comma” or even of a slit instead of the usual comma shape. However, in brachycephalic animals examination of the nasal vestibulum is impossible without an endoscope. A second stenosis - the narrowest location in the nasal entrance - is not accessible with the naked eye and is unfortunately not affected by the various common techniques to enlarge stenotic nares. At the end of the vestibulum nasi, at the transition to the nasal cavity, a prominent oval fold courses from ventro-medial to dorso-lateral. This "closing fold" fits in most cases exactly between the two plicae parallelae within the dorsal and medial part of the vestibule, causing a severe stenosis.

We developed a new technique, a Nasal Vestibuloplasty to correct this. Paying close attention to avoid laceration of either the nasolacrimal duct or the opening of the duct of the lateral nasal gland, the dorso-medial and caudal portion of the ala nasi is resected. This technique removes the major parts of the ala and results in a wide and open vestibule. After discouraging initial results, we decided to avoid any type of thermal energy at the nasal entrance. Our long-term observations showed thermal modalities to create a cicatricial narrowing. To perform a nasal vestibuloplasty properly, we consider the use of magnifying optic means and a potent light source as indispensable.

Intranasal Obstruction: Laser-Assisted-Turbinectomy (LATE)

A typical developmental characteristic of brachycephalics is the postnatal growth inhibition of the splanchnocranium. Reduction of the bony framework of an organ to less than a third of its natural size through selective breeding inevitably has major consequences on the structures contained within it. Inside the nose, these are first and foremost the nasal conchae and the nasal passageways.

As with longer-nosed animals, there is a postnatal turbinate growth in brachycephalic animals; however here termination of growth seems to fail. A typical endoscopic finding is the marked contact between turbinate lamellae, leaving no space between mucosal surfaces for airflow. We call this “relative conchal hypertrophy”.

As regular development of the conchae is impaired, they attempt to gain the size ordinarily necessary to fulfill their function and form so-called aberrant conchae into the nasal meatus, obstructing the lumen. We can differentiate between rostral aberrant conchae (RAC) and caudal aberrant conchae (CAC). RAC are defined as parts of the middle or ventral conchae that grow rostrally beyond the point where the plica alaris branches into the ventral nasal concha (VNC). Thus RAC obstruct the middle and ventral nasal meatus. CAC are parts of the middle or ventral conchae that extend caudally into the nasopharyngeal meatus (NPM).
This causes a significant rise in intranasal airway resistance. Measurement of intranasal airflow resistance (impulse oscillometry, excluding influence of nares and soft palate) revealed marked intanasal restriction of airflow.

For a dog, drastic reduction of nasal breathing means that it loses its principal organ of thermoregulation and is no longer capable of evacuating body heat sufficiently in the event of physical effort, excitement or even warm ambient temperatures.

We developed a new technique, Laser-Assisted-Turbinectomy to correct this obturation. Endoscopically a DIODE-Laser fibre was used to remove obstructive conchae thus creating open intranasal airways. The first part of the LATE procedure aims at RAC and obstructing parts of the VNC. In smaller dogs (Pug, French bulldog < 12 kg BW) only a complete resection of the VNC creates intranasal airways of sufficient width. Initially the transection line follows the bony basal lamella of the VNC along the lateral attachment to the maxillary bone. At its ending, a turn medially and downward is necessary, aiming at a point lateral to the cranial opening of the NPM. Here the ventral nasal concha ends as a mucosal fold. In larger dogs (English bulldog, French bulldog >12 kg BW) a partial resection of the VNC is possible to achieve a comparable result.

The aim of the second part of the LATE procedure is to ensure that the lumen of the NPM is free of CAC. They arise either from ethmoturbinates penetrating the gap between the horizontal lamina of the ethmoidal bone and the vomerine ala; or they are a caudal continuation of the VNC. By this point in the procedure, the latter have probably already been removed in the preceding surgery. However, if the CAC are of ethmoidal origin, they must be resected cautiously at their dorsal origins. With LATE we can resect all blocking structures and succeed in creating a patent intranasal airway.

Pharyngeal Obstruction: Volume Reduction of Soft Palate and Nasopharyngeal Collapsibility

Breeders have obviously been very successful in reducing the bony cranio-facial structures of brachycephalic animals; however, they failed to ensure reductions of the corresponding soft tissues. The problem of redundant masses of soft tissue is well known, but remains a surgical challenge. Shortening of the overlong soft palate does not reduce its thickness. The soft palate of 10 kg brachycephalic dogs can be three times thicker than the palate of a normal dog of 40 kg BW, occupying valuable space in the nasopharyngeal airways. The "meat-in-the-box" model facilitates the understanding of upper airway collapsibility.

At present, we are evaluating techniques to reduce the thickness of the soft palate and to simultaneously stiffen the tissues. After discouraging initial long-term results, we now avoid any thermal energy (Laser, HF-surgery, Ligasure, Coblation) for any soft palate procedure. Long-term observations showed thermal modalities to result in greater scar tissue contracture, thus narrowing the caudal lumen of nasopharynx.

The nasopharyngeal lumen can also be reduced because of enlarged tonsils and an oversized tongue, the latter especially in French Bulldogs.
Laryngeal Obstructions: Laryngocoelectomy and Stiffening of a Collapsed Larynx

*Laryngocoeles* (laryngeal saccules) of the lateral laryngeal ventricle are very common in brachycephalic dogs. There has been some dispute over surgical removal of these structures. In our opinion, a decision on whether to perform surgery can be made quite simply: the patient is placed in the prone position (anaesthetized but unintubated); the tip of the endoscope is placed upon the epiglottis allowing a clear view of the rima glottides (that is to say upon vocal fold and potential laryngocoele). Now the mouth is closed slowly as the dog breathes spontaneously. Usually the glottis opening narrows now. If laryngocoeles overlap the V-shaped contour of the vocal folds (thus causing an additional narrowing of the rima glottides), a laryngocoelectomy should be considered. If parts of the laryngocoele are sucked into the airway, surgical removal is strongly recommended.

We perform the laryngocoelectomy with a diode laser using 1 to 2 watts (max.) and consider a microlaryngoscopic approach as essential to achieving a complete and safe resection. After a basal circumferential transection of the thick superficial layer, the interior mass extending deep caudolaterally is dissected between vocal fold and ventricular muscle, which serve as caudal and rostral anatomical landmarks.

*Laryngeal collapse* is considered as a complication of BAOS. Sometimes it is described as the “end stage” of this disease. We see more and more very young patients with distinct collapse of the larynx, and consider that laryngeal collapse is probably an independent disorder. This seems to be more a problem in Pugs than in Bulldogs. An alarming loss of cartilage rigidity affects both the larynx and the trachea.

At present, we are evaluating techniques to resect any collapsing / obstructive mucosal and cartilaginous tissue which is sucked into the glottic lumen during inspiration:

a) Microlaryngoscopic partial arytenoidectomy, performed "cold" or with a diode laser;
b) laser assisted external laryngeal stiffening (LAELS);
c) "Piriform stretching", applying surgical tension between the partially resected arytenoid and the piriform recess

In order to prevent tissue collapse into the glottis lumen are similar procedures to stabilise flaccid tissue; results thus far have been encouraging.

Closing Remarks

It is a fascinating challenge to develop new surgical techniques. However, in case of brachycephalic surgery it is nothing else but surrendering to the stubbornness of kennel clubs and breeders. Brachycephaly is a purely man-made disease. It represents a demonstrable failure of Kennel clubs and their scientific advisers. Dogs of formerly healthy breeds meanwhile are unable to cope with a walk of over ten minutes walk in springtime.
It is high time for a radical rethink in brachycephalic breeding. Veterinarians - as the experts in animal health and welfare - should play a much more active role in the public discussion. Up until now, "strong leadership" has been sadly absent. Rather than the minor initial efforts we see, breeding standards must be revised much more rigorously, based solely on animal health, not on cosmesis. The two countries responsible for brachycephalic breeding standards must be accountable. To date there is no reliable "quality control" in dog breeding and for that reason lay people are still allowed to design their latest fashion animals.

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Unzipped: Hypospadias Case Report and Review

Dr. Jane Ladlow

Hypospadias is a rare congenital developmental anomaly that results in the urethra opening ventral and caudal to its normal anatomical location. It is caused by incomplete fusion of the urogenital folds during embryonic development and affects both sexes. It has been reported in many species, including the dog, sheep, cow, goat, mouse, non-human primates and humans.

The aetiology of hypospadias in both dogs and humans is still unknown. Inheritance is thought to play a role in approximately 20-25 percent of human hypospadias, while in the canine the Boston terrier appears to be over represented as an affected breed. Reduced response to testosterone stimulation or a reduction and/or delay in testosterone production may be responsible for hypospadias development, while studies in other species suggest that hypospadias may be caused by genetic defects, hormonal teratogens such as progesterone and oestrone, or non hormonal factors such as hypovitaminosis A, anticonvulsant drugs and viruses.

In the male, hypospadias is manifest by varying degrees of urethral and corpus spongiosum deficiency, and is often accompanied by failure of fusion of the prepuce and underdevelopment or absence of the penis. Male hypospadias are classified according to the location of the urethral meatus opening which may occur anywhere from the penile tip to the perineum. Hypospadias is associated with a high incidence of concurrent urological, and non-urological congenital abnormalities in both the dog and man. In man it is reported that as many as 4 in 1000 male births are affected by hypospadias, with the most common concurrent congenital abnormality being cryptorchidism which affects approximately 9% of hypospadias sufferers. Proximal hypospadias ranging from a proximal penile to perineal area occur at a frequency of less than 20% in human male cases. There is currently no data documenting the relative frequency of differing types of hypospadias in dogs. The most commonly reported concurrent congenital abnormalities afflicting dogs suffering hypospadias are cryptorchidism, anorectal and renal defects.

Surgical correction of hypospadias has been described in limited detail within the veterinary literature. This is in stark contrast to the human literature which documents over 250 techniques described for surgical correction of hypospadias in the male within the last century. Techniques described in the veterinary literature primarily address cases where the urethral meatus is located distal to the scrotum, with the objective to correct side effects such as urine pooling within the prepuce, or exposure of the penile tip from a malformed prepuce. Techniques recommended to address severe hypospadias such as the one presented in this report usually include a
combination of genital amputation and urethroplasty. More recent surgical case reports include a tubed bipedicle flap as described by Pavletic; and a tubularised incised plate urethroplasty, as recently described by Adelsburger and Smeak. Techniques to replace segments of urethra using full thickness bladder wall sections, and oral mucosa grafts which have been tubularised, are popular techniques employed by human urogenital plastic surgeons. These techniques have also been previously described in the dog.

The following case report discusses a case of severe perineal hypospadias associated with anogenital cleft, imperforate anus and bilateral cryptorchidism in a male Doberman pinscher. A new reconstructive technique was used to create a urethral tube from the redundant prepuce in order to achieve transfer of the urethral meatus from a perineal to inguinal region. The procedure was performed to improve control of recurrent urinary tract infections.

Separation of the shared ano-urethral mucosa and creation of a functional anus were considered the essential first step in aiding control of constipation and recurrent UTIs. The position of the urethral meatus created in procedure 1 was proximal to that of a typical perineal urethroplasty, which when performed in the dog is often associated with unacceptable urine scalding, recurrent bacterial UTIs, and potential development of struvite urocystoliths. A second procedure was planned to locate the urethral meatus more distally by using the malformed preputial tissue and its mucosa as a transposition graft. Due to the length of the preputial graft there was concern that compromise to the blood supply of the distal graft extremity may occur when transposed. The procedure was thus performed in a multistage fashion as described for repair of severe proximal hypospadias repair in humans. The purpose of the multistage procedure was to promote development of collateral blood supply to the preputial flap, maximising its chance of survival.
REFERENCES


Cancer in the Genes:  
Histiocytic Sarcoma in Flat-Coated Retrievers and  
LUPA

Dr. Jane Dobson

It is generally well known within the veterinary profession that different breeds of purebred dog, suffer from different types of cancer: eg German Shepherd dog and haemangiosarcoma, St Bernard and osteosarcoma, Bullmastiff and lymphoma, and that some breeds eg Boxer and Golden Retriever are more prone to a variety of tumours than other breeds. This is all evidence of underlying genetic factors being involved in the aetiology of cancer in these breeds.

At Cambridge our interest has been in the flat-coated retriever and we have spent many years studying the tumours affecting this breed and working with owners and breeders to try to identify whether there is a genetic link. We have shown that the flat-coated retriever is a breed at risk of development of histiocytic sarcoma (HS) but in contrast to the disseminated form of disease recognised in the Bernese Mountain dog, most reports of HS in flat-coated retrievers describe a localised lesion affecting the musculature or fascia of limbs. We have recently reviewed data and material received through an ongoing flat-coated retriever tumour survey to better define the presentation of HS in the breed and to determine the utility of subclassification of tumours arising at different sites by histology and immunohistological phenotyping.

Data on 180 dogs bearing HS-like tumours was available for review and this showed that whilst the majority (101 lesions, 57%) were primary limb lesions, 47 dogs (26%) had visceral, mainly splenic lesions with no peripheral primary tumour. A detailed histological and immunohistological review of 20 limb tumours and 20 splenic tumours showed that two distinct phenotypic subtypes could be identified: a histiocytic subtype, most prevalent in the splenic tumours and a histiocytic-spindle-pleomorphic subtype, mainly seen in the limb tumours. Despite their variable morphology, all tumours expressed MHC-II and the leukocyte antigen CD18, but only those tumours in the spleen consistently expressed CD11d. The majority of tumours also contained a mild to moderate infiltrate of T lymphocytes.

Canine breed predispositions to cancer and other diseases prevalent in the human population, e.g. heart disease and diabetes, have formed the basis for the “LUPA” project, funded by the EC under the 7th Research Framework Programme. Veterinary Schools in 12 European countries have joined together in a collaborative effort to collect DNA samples from purebred dogs both healthy and affected by: Cancer, Cardiovascular disease, Diabetes mellitus amongst others. The purpose is to compare the genome of large cohorts of healthy and affected dogs by genome wide association (high
throughput SNP genotyping) followed by fine mapping the candidate genes, to identify defects / genes that might be implicated in disease development. This would allow an understanding of the mechanisms and pathways underlying the pathology. For Cancer the target tumours and breeds are:

- Mammary tumours – English Springer Spaniel & others – Lead Institution: Uppsala
- Melanoma – Schnauzer, Poodle, - Lead Institution: Rennes
- Soft tissue sarcoma – Golden Retriever, Rottweiler – Lead Institution: Utrecht
- Haemangiosarcoma – German Shepherd dog – Lead Institution: Cambridge

For more information please visit: www.eurolupa.org.
INTRODUCTION

Diagnostic angiography has played an important role in human radiology since the description of percutaneous arterial access by Seldinger in the 1950s. Since that time advances in imaging technology and medical devices have transformed a once purely diagnostic modality into a widespread and evolving therapeutic subspecialty of human medicine with constantly expanding potential. Interventional radiology (IR) is defined as the use of these contemporary imaging modalities to gain access to different structures throughout the body in order to deliver therapeutic materials for a variety of conditions. Interventional endoscopy (IE) uses endoscopes instead of, or in addition to fluoroscopy, to facilitate access into different structures most commonly through natural orifices. Both IR and IE techniques have provided therapeutic options for diseases once deemed untreatable and have even become considered the standard of care for a variety of human conditions.

While similar potential exists in veterinary medicine, limitations in imaging equipment, access to training, and material expense has hindered the routine use of these procedures until recently. Like other forms of minimally-invasive surgery, both IR and IE have the potential to reduce peri-operative morbidity and mortality rates, shorten anaesthesia times and hospital stays, and some less equipment-intensive procedures can also reduce procedure costs. While these benefits of IR and IE have been clearly demonstrated in a variety of human settings, similar studies have not been routinely performed in veterinary medicine to date. The real benefit of these procedures is not simply to replace more invasive and complicated surgical procedures with excessive associated morbidities but rather to provide options to patients for whom standard traditional therapies have been declined due to excessive morbidity, have failed, or are associated with poor outcomes. Disadvantages of these techniques are mostly relative but include the required technical training that is not yet routinely available in most veterinary programs as well as the considerable expense and investment in both the capital equipment required to perform the procedures and the necessary inventory of guide wires, sheaths, catheters, balloons, stents and embolics.

EQUIPMENT

Imaging - Fluoroscopy

Fluoroscopy is an essential tool for performing interventional radiology procedures. The most common units found in veterinary hospitals include multi-purpose units (fixed, stationary units with radiography capabilities) or
mobile C-arms (smaller units that can rotate around a patient providing tangential views but sacrificing the power and image quality of the fixed units). Larger floor-mounted or ceiling-mounting C-arms combine the flexibility of the C-arm with the power of the stationary units but are significantly more expensive and their accessibility to veterinary hospitals remains limited for the time being. When using the more common mobile C-arms in surgical suites, it is important to have a radiolucent table. Some standard OR tables are thin enough to permit fluoroscopy when the patients are small and placed at the end of the table. Alternatively, the c-arm and patient may be positioned such that the imaging can be performed in lateral fashion across instead of through the table. If possible, carbon fiber or Plexiglas tables can be used to facilitate fluoroscopy in the OR conveniently. More expensive fluoroscopy tables are equipped with a “floating” tabletop configuration to facilitate patient positioning without moving the more bulky C-arm.

Radiation exposure can be substantial during prolonged interventional procedures so the operator should review radiation safety guidelines and reduce exposure as much as possible. Non-essential people should not be in the suite during fluoroscopy, particularly when “runs” are performed as the radiation exposure levels are often increased. Proper protective shielding should be worn at all times, preferably using double-shielding in front when possible and avoiding placing one’s back to the machine during exposures. Radiation badges should be worn and regularly evaluated to monitor for increased exposure.

Standard fluoroscopy is acceptable for most of the more common respiratory, urinary, and gastrointestinal procedures, however digital subtraction angiography (DSA) is recommended for the vascular procedures, particularly when performed in small calibre vessels with overlying structures including bone and gut. DSA is a computer software processing program that permits taking an initial non-contrast fluoroscopic image (the “mask”) and subtracting it from every subsequent image during a “run” or series of recorded images. This permits improved vascular imaging and resolution without overlying structures obscuring the view, and allows the operator to access smaller structures more reliably without excessive amounts of contrast. “Roadmapping” capabilities on some systems permit saving these contrast studies and placing them over real-time fluoroscopy images to provide and actual map to guide wire, catheter, embolic, or stent manipulations.

INSTRUMENTS

Access Prior to any vascular interventional procedure, vascular access is first necessary. Venous access is often performed percutaneously while the author prefers vascular cut-down for arterial access, most often to the femoral artery (or branches) or carotid artery. Cut-down permits vessel repair or ligation to prevent post-operative haemorrhage that can be significant in animals often discharged the same day, and strict confinement until complete hemostasis cannot be routinely and confidently assured. Standard intravenous
catheters or entry needles can be used for vascular access. When a simple needle is used for access, a single-wall puncture technique is used. When an arterial (Seldinger) needle is used (hollow cannula with sharp inner stylet) percutaneously, a double-wall puncture technique is used through the target vessel, the stylet is removed and the cannula is withdrawn until pulsatile blood is obtained. A single-wall puncture technique is often preferred, particularly in coagulopathic patients in whom additional vascular punctures could increase the risk of hematoma formation.

**Guide Wires**

Once vascular access is achieved, guide wire access is obtained. Standard spring guide wires are made from an inner metal core wound in an outer Teflon (PTFE)-coated wire and are available in a wide range of diameters, lengths, stiffness, tip configurations, and surface coatings. Variations include super-elastic nitinol alloy cores surrounded by polyurethane and coated with hydromer compounds to make the wires hydrophilic and lubricious in order to facilitate super-selection of small second- and third-generation vessels. In general, the guide wires currently used in veterinary patients for peripheral use range from 0.14"-0.038" diameter and lengths from 150cm-300cm. For larger vessels, access is typically obtained with an 18 or 19 gauge needle followed by 0.035" or 0.038" guide wire placement. In smaller vessels, access may be obtained more easily and safely with a 21 or 22 gauge needle followed by a 0.018" guide wire.

**Introducer sheaths**

Introducer sheaths are recommended for vascular procedures, particularly in prolonged procedures or those in which multiple devices will be used. Sheaths and their associated vascular dilators permit safe, controlled, confluent dilation of the entry vessel and subsequent protection from vascular damage or haemorrhage during the procedure. Convenient side-ports permit simultaneous flushing with heparinised saline if indicated or contrast angiography if necessary. The check flow diaphragm prevents back bleeding through the sheath while permitting placement of various sized catheters, balloons, stents delivery systems, or other devices that could otherwise result in trauma to the vessel or surrounding tissues.

**Selective Catheters**

Following secure sheath placement with a suture, the dilator can be removed and a pre-shaped catheter can be advanced over the guide wire in order to perform selective angiography. These catheters are routinely 4 or 5Fr, tapered to 0.035" or 0.038" guide wires, and the operator should make certain the catheter is compatible with the chosen guide wire; A 0.035" lumen catheter will not advance over a 0.038" guide wire. Most catheters are end-hole only (for embolic delivery) but some have multiple side holes useful for power
injection of contrast in high-flow vessels such as for cardiac angiography (pig tail catheters for instance). Microcatheters (typically 3 French or less) are used in combination with microwires (typically 0.010-0.018") and passed coaxially through the preshaped catheter in order to access second- or third-generation vessels without causing vessel occlusion or spasm.

**Balloons**

Balloon catheters can either be low-pressure occlusion balloons or high-pressure balloon angioplasty catheters (percutaneous trans-luminal angioplasty [PTA] balloons). Occlusion balloons are used for temporary occlusion of a vessel to facilitate angiography or redirect embolisation materials away from a non-target organ. These balloons can also be used as flow-directed catheters to allow blood flow to direct the catheter towards difficult to access sites. Balloon angioplasty catheters are filled with CO₂ or dilute contrast agent under pressure in order to dilate and efface strictures or stenoses of the blood vessels or other organs such as the oesophagus, rectum, nasopharynx, trachea, or urethra.

**Drainage Catheters**

A variety of catheters are currently available for surgical or percutaneous drainage of fluid collections (e.g. pleural fluid, peritonitis, abscess, etc) or diversionary procedures (e.g. nephrostomy, cholecystostomy, gastric, etc.). Drainage catheters placed using minimally-invasive, image-guided techniques are available in both locking- and non- locking loop conformations and either can be placed using a modified Seldinger technique (over the guide wire) or a trocar technique (requiring specifically designed catheters that come with a sharp metal trocar placed through a softer inner cannula. The locking-loop or Cope-loop self-retaining catheters are preferred by the authors, due to the suture-locking mechanism that secures the catheter loop, minimizing premature catheter withdrawal or removal by the patient.

**Stents**

Stents are tubular structures designed to maintain or re-establish patency of a lumen that has become obstructed. They are available in a variety of materials, shapes, sizes, strength, flexibility, and various other individual characteristics that define their suitability for a particular structure or environment.

In minimally invasive procedures for veterinary medicine, the most commonly used stents can be categorized into metallic versus non-metallic, self-expanding versus balloon expandable, and covered or uncovered. Stents are named for their diameters and lengths; For instance a 8mm x 40mm stent will be 8mm in diameter and 40mm in length if it expands completely. Stents are routinely obtained pre-mounted on or within a delivery system (self-expanding stents) or on a balloon catheter (balloon- expandable stents). Delivery systems are named for their outer diameter and regard to placement.
through an appropriately sized sheath is important. Particular care must be taken with balloon expandable stents as the stent can slide off the balloon during placement through a sheath if appropriate care is not taken or instructions are ignored.

Metallic stents have largely replaced plastic and silicone stents for many procedures because of the versatility and improved designs, smaller delivery systems, and recent advancements in biomaterials and shape-memory metals. These stents have largely changed from various stainless steel alloys to newer metals such as nitinol, a super-elastic, shape memory nickel titanium alloy with excellent biocompatibility and characteristics that particularly suit it for medical device use.

Self-expanding metallic stents (SEMS) are the most commonly used stents in veterinary medicine and their use has been described clinically (or experimentally) in the respiratory, cardiovascular, urinary, gastrointestinal, and hepatobiliary tracts of animals. SEMS are available in mesh, woven/braided, or laser cut designs. While individual stents are designed and manufactured differently, mesh SEMS are typically "reconstrainable", meaning at some defined point before complete deployment the stent can be recaptured within the delivery system and repositioned or removed. A disadvantage of this stent design is the variable degree of “foreshortening” encountered during stent deployment. This characteristic means that as the stent expands during release from the delivery system it will shorten to assume its ultimate diameter and length. This shortening will depend upon the degree to which the stent ultimately expands within the lumen in which it is placed and can often be difficult to predict precisely. Reconstrainability and foreshortening must be understood and anticipated by the operator when mesh SEMS are being used.

Woven or braided stents are also made from metallic wire but often of much thinner gauge to create a softer, almost fabric-like stent. These stents are not reconstrainable but tend to have minor foreshortening. Woven stents have not demonstrated significant advantage over other more commonly used stents and are therefore not routinely used in veterinary medicine; however they have been used in the respiratory and gastrointestinal tracts of veterinary patients. Laser cut stents are produced from a narrow tube of metal in which a laser cuts the stent design that is later expanded to create the ultimate stent dimensions. The stent then undergoes a finishing and coating process before being cooled and crimped onto a low-profile delivery system to permit placement through small orifices of holes. These stents are made from shape memory metals, often nitinol, that have different properties depending upon the temperature and stress placed upon them. Upon reaching body temperature, the crimped nitinol stent changes properties and resumes its original stent diameter and length. These characteristics have revolutionized stent design and the laser cut stents are one of the most commonly used SEMS in interventional radiology. These stents are not typically reconstrainable (very few exceptions) and have minimal foreshortening.
permitting precise placement across focal lesions. In veterinary medicine, the laser cut stents are most commonly (and successfully) used in the urethra or vasculature but excessive rates of fracture occurred with their use in chondromalacic tracheas of dogs with tracheal collapse (personal experience).

Grafts, or stent grafts, refer to stents with coatings or coverings (covered stents). Coatings vary but include silicone and various types of polytetrafluoroethylene (Teflon/PTFE) materials placed inside, outside, or surrounding the underlying metal structures. Stent grafts have been used in veterinary patients, particularly for recurrent strictures or malignancies that have grown through an uncovered stent. Some disadvantages of covered stents include increased cost, increased implanted material, and larger delivery systems. Care must be taken to avoid occlusion of adjacent structures when covered stents are placed as well, particularly in the vascular systems.

Balloon expandable metallic stents (BEMS) are collapsed and narrow in the resting state and either manually mounted or more commonly pre-mounted onto a balloon catheter. The stent and balloon are positioned across the lesion and as the balloon is inflated the stent expands. The balloon is then deflated and removed and the stent remains in place. BEMS are available in both covered and uncovered designs and are ideal for precise placement of short, rigid stents in areas that are not likely to be compressed externally. Disadvantages include the relatively short lengths available, poor flexibility, and static response to compression (i.e., if compressed the stent will remain compressed and not expand). For these reasons, BEMS are only used in veterinary patients routinely for nasopharyngeal stenoses (relatively short strictures often surrounded mostly by bone) and occasionally for urinary tract strictures.

The non-metallic stents are primarily constructed of different polyurethane compounds for use in the urinary tract (e.g. ureteral stent) or bioabsorbable compounds (e.g. polydioxanone, etc.) currently being evaluated in the oesophagus. Ureteral stents are available in a variety of sizes, lengths, double-pigtail loop size and configuration, number of fenestrations, and durometer (a measure of the material stiffness). These stents are placed over a guide wire and positioned with the use of a “pusher” that advances over the guide wire behind the stent. Ureteral stents can be placed temporarily (e.g., following shockwave lithotripsy of a nephrolith) or permanently (e.g., for neoplastic obstruction or ureteroliths for instance).

**Embolics**

Embolics are compounds or devices used to obstruct blood flow to a structure in order to reduce hemorrhage, occlude vascular anomalies, ablate tumors, or more recently, improve local concentrations of certain chemical or biological substances. These agents can be classified as mechanical or particulate, temporary/biodegradable or permanent, and solid or liquid. Not unlike other
devices for interventional radiology procedures, no single embolic is ideal for all situations and each has its advantages and disadvantages.

The most commonly used embolics in veterinary patients are the permanent mechanical devices used for relatively large vessel occlusion such as thrombogenic embolisation coils and more expensive but more controllable custom woven nitinol vascular plugs and occluders. Particulate and liquid embolics are chosen over mechanical agents to embolise the higher-order vessels and capillary beds. More distal embolisation is necessary for tumour ablation and vascular malformations, and while it ensures more definitive distal tissue ischemia (and reduced risk of revascularization), there is also increased risk of tissue necrosis and related consequences of infarction. The most commonly used permanent particulate agents include polyvinyl alcohol (PVA) particles (amorphous/granular or spherical) and hydrogel microspheres. These are an inert plastic available in various particle sizes ranging from 45 to over 1000 microns and embolisation results from initial mechanical vascular occlusion followed by permanent fibrin ingrowth. More recently, a spherical product that is more compressible thereby facilitating delivery through the catheter and resulting in more complete occlusion within the target vessel has replaced the original amorphous/granular product. Liquid embolics have the advantage of passing through the capillary beds of tumours, organs, and malformations permitting complete tissue destruction through to the venous circulation, however this same attribute also increases the risk of non-target embolisation and is more difficult to control than the particulate alternatives.

Glue (most commonly n-butyl cyanoacrylate [NBCA]) has probably been used the most and has been reported for use in vascular arteriovenous fistulas, arteriovenous malformations, and thoracic duct embolisations in veterinary patients. NBCA is a low viscosity, non-radio-opaque, inert agent that polymerizes into a solid once in contact with an ionic substance. Glue is mixed with ethiodized oil (Lipiodol) in a 1:1 to 1:4 ratio to slow the rate of polymerization, depending upon the speed of blood flow through the vascular bed.

**Thrombolytics / Thrombectomy Devices**

Thrombolytics are beyond the scope of this manuscript. The increasing use of vascular access, endovascular procedures, and placement of endovascular devices is likely to increase the occurrence of thrombosis. While venous and arterial thromboses are managed differently, some of the devices can be used interchangeably. Historically, thrombolysis has been performed through systemic venous administration. Recently, more local therapy has been used in a variety of techniques including intra-arterial administration (bolus or constant-rate infusions), intra-thrombus administration via multiple side hole catheter or infusion wire, or mechanical or pharmacomechanical thrombolysis using thrombectomy devices with or without concomitant thrombolytic infusion.
Lasers have become an increasingly important tool in veterinary surgery and interventional endoscopy for tissue ablation and stone management. The diode laser is a continuous laser that emits light at a wavelength of 980nm. This type of laser energy has a high simultaneous absorption in water and hemoglobin, combining both high tissue ablative properties and good hemostasis, making this a good laser for cutting and coagulating tissues. This laser’s main cutting property is by thermal energy. This laser is typically used for tissue ablation such as intramural ectopic ureter laser ablation, cutting the tissue of a persistent paramesonephric remnant, or for nasal and laryngeal reconstruction.

A holmium:YAG (Hol:YAG) laser uses a crystal of yttrium, aluminum, and garnet (YAG) doped with holmium. The beam falls in the near infrared portion of the electromagnetic spectrum (2100 nm) and is delivered in 350μsec pulse durations. The laser energy is absorbed in <0.5 mm of fluid making it a very suitable surgical laser for endourologic applications like laser lithotripsy. The laser energy is delivered to the surface of the uroliths using flexible quartz fibers available in multiple different diameters (200, 365, 550 microns). The Hol:YAG laser combines tissue cutting and coagulation properties, as well as the ability to fragment stones upon contact.

### Contrast Agents

While there are many classes of contrast media available, the most commonly used in interventional radiology are the low osmolality, non-ionic iodinated contrast media such as iohexol. Iohexol is available with different iodine concentrations which should be reported when used; the authors typically use between 240 to 350mgI/ml and often dilute 1:1 or 2:1 saline:contrast. Complications associated with intravascular contrast media are typically mild and relatively uncommon but can include nausea, vomiting, pain, anaphylaxis, hemodynamic effects, and most notably nephrotoxicity. Contrast-induced nephropathy (CIN) remains incompletely understood but likely results from a combination of direct cytotoxicity and prolonged vasoconstriction and impaired renal vascular autoregulation. A safe dose has not been determined but the authors try to use less than 2mls/kg during standard vascular interventional procedures (although occasionally 4-5mls/kg has been used safely with patients that received fluid diuresis for the following day).

### Miscellaneous Devices

There are thousands of ancillary, miscellaneous devices designed to facilitate minimally invasive procedures and their introduction is beyond the scope of the chapter. Some of the more commonly used equipment includes baskets and snares (for retrieval of vascular or intra-luminal foreign bodies, stones, or tumours), various biopsy devices (for intra vascular or intraluminal use to obtain samples), and flow-switches or adapters (to help perform coaxial procedures using a variety of different equipment described above).

**REFERENCES AVAILABLE UPON REQUEST**
Congenital Vascular Anomalies: Coils and Shunts

Dr. Chick Weisse

HEPATIC VASCULAR ANOMALIES

The categorization of liver vascular anomalies is often confusing and but the most recent classification suggests three separate categories of liver vascular disease: (1) Congenital portosystemic shunts (IHPSS and EHPSS), (2) Disorders associated with abnormal hepatic bloodflow or portal hypertension, currently termed Primary Hypoplasia of the Portal Vein (PVH), and (3) Disturbances in outflow. The second category (PVH) remains the most confusing, and includes processes that may or may not result in portal hypertension. These are termed PVH with portal hypertension and PVH without portal hypertension. Examples of PVH with portal hypertension include non-cirrhotic portal hypertension (NCPH), and hepato-portal fibrosis/veno-occlusive disease. PVH without portal hypertension was previously termed microvascular dysplasia (MVD).

IHPSS

Single, extrahepatic PSSs are amenable to relatively uncomplicated surgical attenuation, however surgical repair of intrahepatic PSSs are consistently more challenging. Numerous techniques have been described for intrahepatic PSS attenuation, however morbidity and mortality rates can be very high, even for the most experienced surgeons. The goal of IR techniques for IHPSSs is to reduce the unacceptably high, peri-operative mortality rates associated with traditional open surgical techniques and hopefully improve the outcome for these cases. The author has performed over 100 percutaneous transvenous coil embolisations (PTCE) with a vena caval stent and thrombogenic coils placed within the shunt. Peri-operative complications were mostly minor and peri-operative mortalities were comparatively low versus that reported for traditional surgery.

PROCEDURE:

Percutaneous Transvenous Coil Embolisation

All dogs were treated medically initially following diagnosis of the IHPSS for a period of weeks to months. When possible, CT or MR angiography was performed to delineate the shunt anatomy and obtain caval and shunt measurements under a separate anaesthetic episode. All PTCE procedures were performed under general anaesthesia using standard liver dysfunction protocols and often neuromuscular blockade to minimize respiratory artefact.
during digital subtraction angiography. Peri-operative cefoxitin was administered at 30mg/kg once, followed by 20mg/kg q2 hours during the procedure. Some variation in procedure occurred over the years performing these cases but the basic procedure is described below with slight variation of that originally described by Schneider et al.

Patients were placed in dorsal recumbency with a radio-opaque stent guide placed underneath. The ventral cervical region was clipped, scrubbed, and draped exposing the right jugular vein (preferred over the left jugular vein because of the direct path into the vena cava). All guidewire, catheter, stent and coil manipulations were performed under fluoroscopic guidance. A 3-5mm skin incision facilitated percutaneous placement of an 18 gauge over-the-needle catheter into the right jugular vein. A 0.035” angled, hydrophilic guidewire was advanced through the catheter and into the caudal vena cava. The catheter was removed over-the-wire and replaced with either a 10Fr or 12Fr vascular introducer sheath depending upon the anticipated caval stent size. The sheath was secured in place with a single suture and the dilator removed.

For left or right divisional shunts the animal remained in dorsal recumbency. For central divisional shunts, the animal was turned to lateral recumbency in order to facilitate angiographic identification of the shunt entrance into the caudal vena cava. A combination 4Fr Cobra catheter and hydrophilic angled guidewire combination was used under fluoroscopic guidance to selectively access the shunt. Digital subtraction portal venography was then performed to confirm placement, delineate shunt anatomy and confirm the presence or absence of portal perfusion. If considerable portal perfusion was present (second generation portal vessels or more), balloon occlusion was performed to assess whether complete shunt attenuation would be tolerated. If so, alternate shunt embolisation techniques were used (vascular plug, stent graft, etc.). Otherwise, a combination 5Fr marker catheter and angled, hydrophilic guidewire were advanced into the sheath beside the Cobra catheter and down the caudal vena cava. A digital subtraction caudal vena cavagram was performed under 20cm H₂O positive pressure ventilation (PPV) in order to maximally distend the abdominal vena cava. Maximal abdominal vena cava diameter was then calculated using the marker catheter to determine radiographic magnification. Next, a combination digital subtraction portogram and caudal vena cavagram was performed without PPV to identify the precise location and length of the shunt entrance into the caudal vena cava as well as to determine the maximal intra-thoracic caudal vena cava diameter (non-PPV). Caval diameters and shunt opening lengths were used to choose an appropriately sized, self-expanding metallic stent; typically at least 10-25% greater in diameter than the maximal caval diameters measured and at least 20mm longer cranially and caudally to the shunt opening into the vena cava when possible. Portal pressures were then recorded through the end-hole Cobra catheter and caval pressure measurements were recorded through the marker catheter before stent placement. If resting portal pressures were greater than 20cm H₂O (~15mmHg) or the pressure gradient between the
portal vein and vena cava were greater than 6cm \( H_2O \) (~4.4mmHg), the procedure was aborted, repeat angiography was recommended in three months, and the animal was removed from the study if the procedure was not ultimately performed. Otherwise, the Cobra catheter was removed from the portal vein, a 180cm floppy-tip PTFE (Teflon) guidewire was advanced down the marker catheter and the marker catheter removed.

The stent delivery system (containing the stent) was advanced over-the-PTFE wire and deployed under fluoroscopic guidance to ensure that the entire mouth of the shunt was spanned by the stent. Following stent deployment, the delivery system was removed and the 4Fr Cobra catheter and hydrophilic guidewire combination were used again to select the shunt through the stent interstices. Following shunt access, a repeat digital subtraction venogram was performed to confirm stent placement across the entire shunt orifice. Typically, repeat pressure measurements were obtained to determine if the stent placement had raised the pressure within the shunt. Thrombogenic stainless steel coils (usually 8mm diameter x 5cm length) were then advanced through the Cobra catheter and deployed into the shunt under fluoroscopic guidance; the presence of the caval stent prevented migration of the coils into the caudal vena cava. Coils were subsequently added with intermittent shunt pressure measurements taken to avoid creating portal hypertension. Although the guidelines changed throughout the period of the study, coils were typically added until the shunt mouth was covered with coils (initial cases) or the shunt pressures had increased between 6 and 10cm \( H_2O \) or maximal pressures approached 20cm \( H_2O \) (majority of cases). Ultimate shunt and caval pressures were recorded, the jugular sheath was exchanged for a 7Fr multi-lumen catheter, and the animal was recovered from anesthesia.

**LESSONS LEARNED:**

*Lessons learned or questions raised concerning DIAGNOSTIC IMAGING include:*

- CT and MR angiography are well tolerated and facilitate identifications of uncommon shunt anatomy, however certain abnormalities are underestimated using these techniques. For instance, multiple small intrahepatic shunts are often not identified on standard cross-sectional imaging. These abnormalities are better identified with traditional contrast portography. It is not clear if dual phase CT provides us with additional important information at this time (as compared to single-phase).

- MRA(using gadolinium) may permit single procedure IHPSS imaging and treatment in order to avoid excessive iodinated contrast use associated with CT angiography following by angiography.

- Even “typical” IHPSS have variant hepatic vein anatomy. Does location of HV entrance into the PSS affect results of attenuation? It is
conceivable that intra-hepatic vein shunting (acquired intrahepatic PSS) may occur ore readily in these patients. Examples will be discussed.

Lessons learned or questions raised concerning TREATMENT include:

-A certain small population of IHPSS patients have “significant” portal:systemic venous pressure gradients (or resting portal pressures) before treatment. This is counter-intuitive in animals with PSS in that reduced portal pressure gradients would be anticipated, and this has prevented treatment in some cases. Are there small vascular windows or narrowings present that are not identified on cross sectional imaging with relatively wide slices? This suspicion has been raised as pull-out pressure tracings confirm short, focal areas where pressure gradients exist.

-Which is more important in preventing the development of complications associated with portal hypertension following IHPSS treatment; Total portal pressure or pressure gradients? During surgery we rarely measured CVP and using IR techniques, we always measure CVP.

-During portography, when multiple small intrahepatic shunts are identified, this is almost exclusively associated with and elevated portal pressure and/or pressure gradient. Are these congenital shunts or acquired IHPSS resulting from a congenitally narrowed IHPSS?

-Acquired Intrahepatic Portosystemic shunts: Originally believed to only acquire EHPSS, there is more evidence that IHPSS can be acquired as well. Do the same criteria for shunt attenuation (no greater than ~10cmH2O rise in portal pressure and/or no greater than ~20cmH2O total portal pressure) hold for attenuation of IHPSS? Although there is no documented difference between HV attenuation and PV attenuation, the vascular bed receiving the congestion is intrahepatic with the former and extrahepatic with the latter. Does this matter?

-DO NOT PERFORM IHPSS SHUNT ATTENUATION IN THE FACE OF GI ULCERATION/HEMORRHAGE. The authors currently perform endoscopy and biopsy of all IHPSS cases before treatment and the overwhelming majority of these dogs have some degree of inflammatory bowel disease, sometimes including GI ulceration. Approximately 17% of patients have evidence of GI bleeding before treatment. Elevation of portal pressures with the presence of GI ulceration can lead to severe GI hemorrhage and death. All animals are maintained on omeprazole therapy for life. Initially a long-term mortality rate of 30% in IHPSS PTCE animals was caused by GI bleeding in ~50% of deaths. Lifelong antacid therapy has reduced the mortality rate to 12.5% with fewer than 4% secondary to GI bleeds. Is lifelong omeprazole therapy safe?
Lessons learned or questions raised concerning FOLLOW-UP include:

- Is return to normal bile acids concentrations necessary? Should this be the goal of therapy? The majority of patients receiving IHPSS PTCE do not have return to normal liver function and some have even been identified to have no development of portal branching, although pressure gradients continue to exist. Is hepatic vein congestion and reduced portal bloodflow drainage consistent with improved portal bloodflow? Maintenance of a portal gradient appears to coincide with improved clinical signs. Can this be adequate or should additional interventional/surgical treatment be instituted?

- Development of “longer term” (greater than 2-4 weeks) post-procedural ascites is most commonly associated with hypoproteinemia and NOT excessive portal hypertension (although they can occur simultaneously). In our population of cases, this has most commonly been associated with a GI bleed and subsequent hypoalbuminemia and hypoglobulinemia and the resultant reduction in oncotic pressure. This has not always been confirmed but aggressive medical therapy with GI protectants has resulted in resolution of the clinical signs in most of the few patients we have identified with this complication. No therapy for portal hypertension has been necessary.

- Approximately 18% (13/73) of cases required additional coiling procedures

References available upon request
Medical Management of Portosystemic Shunts
Dr. Michael Herrtage

Abstract
Medical management of portosystemic shunts involves the control of hepatic encephalopathy. Hepatic encephalopathy (HE) results from the liver's failure to detoxify waste and is particularly seen in acquired and congenital portosystemic shunts (PSS) where portal blood is not filtered properly before reaching the general circulation. The prime consideration in the management of hepatic encephalopathy is to identify and correct any factors that may precipitate or exacerbate the encephalopathy. The principle of treating hepatic encephalopathy is to reduce the formation and absorption of toxins from the gastrointestinal tract by reducing protein intake and suppressing or eliminating urease-producing intestinal bacteria.

Pathophysiology
There is still much discussion about compounds and mechanisms involved in HE but the following are implicated: ammonia; mercaptans; short chain fatty acids; reduced branched-chain amino acids and increased aromatic amino acids; gamma-aminobutyric acid (GABA) and GABA-like agents and endogenous benzodiazepine receptor ligands.

Ammonia has always been considered the most important neurotoxin in HE although serum ammonia concentration does not invariably correlate with the severity of clinical signs. It originates primarily from the gastrointestinal tract where it is produced in the following ways:

1. Bacterial breakdown of amines, amino acids and purines
2. Action of bacterial and intestinal wall urease on urea, which normally diffuses from the blood across the gut wall in significant amounts. This is actually probably the most important source of ammonia absorbed from the gut. In a normal animal, about 30% of urea made in the liver diffuses back in to the gut.
3. Enterocyte catabolism of glutamine as their major fuel source.

In a normal animal, the ammonia in the portal blood is efficiently extracted by the liver and converted to glutamine or to urea via the urea cycle. In animals with PSS, some of this ammonia bypasses the liver and reaches the systemic circulation, including the brain, in abnormally high concentrations. Ammonia readily crosses the blood-brain barrier but the brain does not possess an effective urea cycle so ammonia is metabolised to glutamine by an energy dependent reaction. Interestingly, CSF glutamine concentration in humans with acquired PSS reflects brain dysfunction much better than any other parameter identified so far. Some studies suggest that in HE the cerebrum
may be more permeable to ammonia than normal, perhaps explaining why signs of HE may occur when blood ammonia concentrations are normal.

Mercaptans are synthesised from dietary methionine by colonic bacterial metabolism. The short chain fatty acids implicated in HE originate from colonic microbial fermentation of fibre and not from dietary fat. Mercaptans and short chain fatty acids are thought to act synergistically with ammonia to cause HE by altering central nervous system sodium-potassium ATPase activity.

Amino acid ratios also appear to be important in the pathogenesis of HE. Dogs with HE have been found to have a reduction in blood concentration of branched-chain amino acids (valine, leucine, isoleucine) and an increase in aromatic amino acids (phenylalanine, tyrosine, tryptophan). Aromatic and branched-chain amino acids compete for transport across the blood-brain barrier so these dogs also have an increase in aromatic amino acid concentration in the brain. Aromatic amino acids may promote HE by conversion to false neurotransmitters and serotonin (an inhibitory neurotransmitter) while true neurotransmitters such as dopamine and noradrenaline may become depleted. Infusion of branched-chain amino acids into dogs has been shown to produce an improvement in HE and giving branched-chain amino acids orally to humans also results in an improvement in HE. In addition, the use of increased branched-chain amino acids in TPN amino acid solutions in humans may allow a higher concentration of protein to be fed without clinical signs, so more effectively counteracting protein-calorie malnutrition in these patients. Recent interest in man has focussed on the addition of extra ornithine aspartate to enteral diets or parenteral nutrition: it has been shown to reduce blood ammonia concentration and HE in man to a similar extent as lactulose. This is because ornithine is a substrate in the urea cycle, converting ammonia to urea.

GABA is the most important inhibitory neurotransmitter in the brain and some studies show an increase in brain GABA concentration in HE although other studies show a normal or decreased concentration so its status in HE is presently unclear. The GABA receptor in the brain is a complex glycoprotein also containing receptors for benzodiazepines and barbiturates which both increase GABA activity. Interestingly, an increase in plasma concentration of benzodiazepine-like ligands has been recognised in humans with HE and their concentration correlates with the severity of HE. The source of these ligands is not known (may be derived from food in the gut) but some humans with acquired HE improve when given the benzodiazepine receptor antagonist flumazenil (although the results of the various human studies remain equivocal). However no controlled trials have been performed on the use of this drug in dogs with PSS. In addition, recent work in Holland suggests these endogenous benzodiazepine-like ligands are not present in the CSF of dogs with congenital or experimentally produced PSS - although all these dogs were fed the same diet (Hills K/D) - perhaps other diets may contain more.
The development of HE is often associated with a precipitating factor, which increases blood concentration or effect of encephalopathic substances. Such factors include:

- A recent high protein meal
- Gastrointestinal bleeding e.g. due to parasitism or secondary to portal hypertension in acquired PSS
- Constipation which increases time for ammonia production in colon
- Azotaemia which will increase blood ammonia concentration
- Hypokalaemia which leads to metabolic alkalosis due to increased renal sodium-hydrogen exchange
- Excessive diuretic therapy leading to hypokalaemia
- Alkalosis which allows more ammonia to cross the blood-brain barrier
- Transfusion of stored blood, which contains a lot of ammonia
- Bacterial infection increasing catabolism
- Sedatives, tranquillisers, anticonvulsants and anaesthetics
- The use of methionine-containing drugs

TREATMENT

1) Acute hepatoencephalopathic coma

Intensive medical management is essential. Hepatoencephalopathic coma is rare. Occasionally occurs in animals with congenital PSS but is commoner with acquired PSS. It is caused by cerebral oedema resulting in generalised dysfunction and, although the prognosis is poor, the condition is potentially completely reversible so treatment is worthwhile. The crisis is often associated with a precipitating factor (see earlier) and this should be identified and removed or treated if possible.

Treatment involves the following:

- NIL BY MOUTH (very important) and intravenous fluid support - but do not overload with fluids or increase cerebral oedema.
- Monitor blood potassium - avoid hypokalaemia - add potassium to fluids if necessary.
- Monitor blood glucose concentration - avoid hypoglycaemia, which is common and may cause permanent brain damage. Add dextrose to fluids as necessary.
- Remove faeces and ammonia from colon with warm enemas. Solutions containing povidone-iodine diluted 1:10 with warm water, with or without the addition of lactulose and neomycin, are recommended. Lactulose enemas are the most effective. Continue until the fluid runs clear, but take care not to cool the animal, particularly small patients.
- Antibiotics: neomycin via retention enema and/or intravenous ampicillin and metronidazole as prophylaxis against bacteraemia and septicaemia
  - Other, careful drug support as necessary: frusemide to reduce cerebral oedema (but beware causing hypokalaemia or azotaemia); diazepam if the animal begins to seizure (in spite of its interaction with the GABA receptor) but at half normal dose (0.25-0.5 mg/kg iv ) or using propofol (1.0-3.5 mg/kg as a bolus injection or 0.01-0.05 mg/kg/minute as a constant rate infusion).
• Gastroprotectants should be used if gastroduodenal ulceration is suspected.
• Vitamin K1, fresh or fresh frozen plasma or fresh whole blood should be considered if bleeding continues.

If the animal recovers from the crisis, its prognosis is not necessarily poor. We have seen animals with congenital PSS present in coma in our clinic but go on successfully both to long term medical management and to surgical ligation.

2) Chronic hepatic encephalopathy

For long term control of hepatic encephalopathy, dietary management is important. The use of lactulose, a semi-synthetic, non-absorbable disaccharide, is indicated. Lactulose is hydrolyzed by colonic bacteria to organic acids, which acidify the colonic contents. This reduces ammonia absorption and acts as an osmotic laxative, which reduces the number of colonic bacteria. Lactulose is given orally at a dosage of 0.5 to 2.5 ml three times daily. Diarrhoea is a sign of overdosage. Antibiotics are helpful in controlling hyperammonaemia by reducing urease-producing intestinal bacteria. A combination of ampicillin and metronidazole has proved successful in the respect.

Dietary management

Dogs with liver disease should receive a highly digestible, high quality protein diet and should not be protein-restricted unless there is overt hepatic encephalopathy. Small quantities of food given frequently during the day improve digestion and absorption in the small intestine. This also reduces the amount of protein entering the colon and thus decreases ammonia production. It is important to keep dogs eating so as to prevent catabolism of their own protein.

The following is a general consideration of dietary therapy of liver disease, with a special emphasis on hepatic encephalopathy:

Protein is the most important consideration. High quality, highly digestible, in just the right quantity, i.e. enough to prevent catabolism of body protein but not too much since this requires hepatic metabolism and results in increased blood ammonia. Protein needs to be highly digestible to stop it reaching the colon where colonic bacteria will break it down with the production of ammonia, which contributes to hepatic encephalopathy.

Severe protein restriction is only indicated when necessary to stop clinical signs of hepatic encephalopathy, i.e. only use low protein diets if the severity of neurological signs dictates. Otherwise best to use a medium protein diet e.g. Waltham hepatic support diet, which is only moderately protein restricted. Base your decision for the degree of protein restriction necessary on the clinical signs and on the previous dietary history of animal. For example, if
hepatic encephalopathy only occurs when a dog eats puppy food or whiskers, only moderate restriction will be necessary.

Recent evidence suggests that protein requirements may even be increased in man and rats with liver disease. Adequate protein is vital to allow hepatocellular function and regeneration. It is important to realise that protein restriction is not slowing the disease process but only controlling the clinical signs (similar to dietary management of renal failure). In PSS where severe protein restriction may be necessary in some cases to control encephalopathy, monitor plasma albumin regularly and adjust the diet if the albumin concentration falls. Also, if severe protein restriction is necessary in puppies with PSS, warn the owners that the puppies’ development will be affected, especially in the large breeds such as Irish wolfhounds.

High quality protein means contains all essential amino acids in large amounts. The body has no pool of stored amino acids. Therefore, if a meal does not contain all the amino acids necessary to build body protein, the amino acids, which are present will be “wasted” and broken down for energy. One way to quantify the quality of protein is its "biological value" which is the percentage of the protein eaten which is absorbed and retained, i.e. not lost in faeces or urine. Some examples of biological values of proteins:

<table>
<thead>
<tr>
<th>Protein</th>
<th>Biological Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>100</td>
</tr>
<tr>
<td>Fish meal</td>
<td>92</td>
</tr>
<tr>
<td>Milk</td>
<td>92</td>
</tr>
<tr>
<td>Soybean</td>
<td>67</td>
</tr>
<tr>
<td>Whole corn</td>
<td>45</td>
</tr>
<tr>
<td>Gelatin</td>
<td>0 (contains no tryptophan, an essential amino acid)</td>
</tr>
</tbody>
</table>

An ideal protein to use in liver disease is cottage cheese. It has high biological value and is low in aromatic and high in branched chain amino acids. It has half the lactose per calorie of yoghurt or milk. Its only problem is that it is low in arginine, which is particularly important in cats. Eggs are a good source of arginine, but are also high in methionine, which contributes to hepatic encephalopathy. Fish is not ideal as it is high in purines, which are metabolised to urate and uric urolithiasis is a problem in many dogs with PSS. Vegetable protein is relatively poor quality but is used in man because it is also a good source of soluble fibre, which is anti-encephalopathic (see below). The easiest way to feed high quality protein is to feed a proprietary diet (eg Waltham hepatic support) and adjust protein concentration to individual’s clinical signs i.e. add more protein (cottage cheese) if blood albumin drops or dilute diet with carbohydrate (rice or pasta) if hepatic encephalopathy recurs.

**Carbohydrate** should be highly digestible so animal can use it as primary calorie source, reducing need for hepatic gluconeogenesis from fat and protein. However, carbohydrate metabolism is usually disrupted in hepatic disease: impaired hepatic gluconeogenesis, glucose intolerance due to changes in degradation of cortisol, insulin and glucagon and the effects of hypermetabolism and stress. Therefore, complex carbohydrates and fat will be better used as an energy source by the animal with liver disease than glucose.

**Fats.** No special advice in liver disease and dietary fat is important as contributes to calories and palatability of diet and animal may have reduced carbohydrate metabolism (see above). Previous advice to restrict fat in liver disease was based on two flawed ideas:

- SCFA involved in HE result from colonic fibre metabolism and not from digestion of ingested fat.
• Steatorrhoea due to cholestasis and reduction in bile acids reaching small intestine is actually very unusual, even in cholestatic diseases like cholangiohepatitis. Most of these animals can cope with normal amounts of dietary fat and restriction is only necessary if steatorrhoea is recognised clinically. However, some animals may have problems with high fat diets and many renal diets are high fat.

Medium chain triglycerides (like coconut oil) are contraindicated in liver disease as they may worsen hepatic encephalopathy.

Fibre. Recently recognised importance of some fibre in diets for liver disease:
• Soluble fibre reduces hepatic encephalopathy. It is broken down to SCFA's in the colon and these trap ammonia as ammonium ions (similar action to lactulose). Also has a beneficial effect on colonic bacteria, increasing nitrogen incorporation into bacteria and reducing ammonia production.
• Insoluble fibre is also important as it prevents constipation. Constipation is a predisposing factor for the development of encephalopathy since it increases the time available for colonic bacteria to act on the faeces and produce ammonia.

Fibre in moderate amounts is therefore useful but too much will interfere with digestion and absorption of nutrients.

Vitamins. Supplement water-soluble vitamins (B and C). Vitamin C is made in the liver and water-soluble vitamins are loss in PU/PD associated with liver disease, especially in cats. It is recommended that animals (and humans) with liver disease receive a double dose of water soluble vitamins. (Vitamin C is actually synthesised in dogs and cats at about 50% of the rate of most other mammals. It is an important anti-oxidant and its concentration is reduced in stress, so there is the potential for deficiency in liver disease).

Supplementation with fat soluble vitamins is generally to be avoided (even though absorption is reduced due to lack of bile acids) because of the potential for toxicity, except:
• Vitamin E supplementation may be cytoprotective especially in copper toxicity. It neutralises free radicals and some authors use it in any case of chronic hepatitis as a dose rate of 400-600 IU/day in medium-sized dogs.
• Vitamin K supplementation may be necessary if clotting times are prolonged, especially if considering liver biopsy. Dose 0.5-2.0 mg/kg im or sc (oral no good as absorption reduced) Give 12 hours before biopsy and repeat every 7-21 days as necessary (monitor clotting times - whole blood clotting time and OSPT + APTT)
• Vitamins A and D should not be supplemented.

Minerals. Zinc deficiency is common in man with liver disease (reduced absorption and increased urinary loss). Supplementation with zinc improves encephalopathy in many people with liver disease. Zinc also has important roles in liver disease:
• Used in many metalloenzymes involved in the urea cycle (2 out of 5) and in the metabolism of ammonia in muscle
• Reduces copper absorption from gut and copper availability in liver in primary or secondary copper toxicosis cases
• May also reduce collagen laid down in the liver
• May stabilise lysosomal membranes

Supplementing zinc is therefore worthwhile. Some authors recommend it is
used in chronic hepatitis in dogs. Zinc concentrations are increased in the hepatic support diet. If it is added to food, must regularly monitor blood concentrations to avoid toxicity (iron deficiency and haemolysis). Main side-effect at therapeutic concentrations is vomiting.

Recommended dose: 50-100mg elemental zinc divided bid in medium sized dog; 7 mg/day in cats. Give 1 hour before food (reduces incidence of vomiting) and monitor blood concentration every 2 weeks for several months. Aim for 200-400 mg in blood (toxicity at 1000 mg).

Sodium: restriction recommended in liver disease associated with ascites (see below).

**Antibiotics**

Since the reticuloendothelial function of the liver is reduced in liver disease, bacteria absorbed from the intestine may not be removed by the liver and may result in bacteraemia and septicaemia. Thus, antibiotic therapy directed against intestinal anaerobes and aerobes is indicated not only to control hyperammonaemia, but also to prevent bacteraemia or septicaemia. Ampicillin, amoxycillin, cepahlexin and enrofloxacin can be used safely in patients with liver disease and have the advantage of being concentrated in bile. Metronidazole can be used in combination with ampicillin, amoxycillin and cepahlexin to reduce encephalopathogenic, urease-producing organisms.

**Management of ascites**

The management of ascites should include cage rest, dietary restriction of sodium and the administration of diuretics. The presence of ascites does not necessarily require the use of diuretics, however, as some animals with mild ascites will improve with cage rest and sodium-restricted diets alone.

Diuretics are indicated to control more severe ascites. Spironolactone, an aldosterone antagonist, used alone or in combination with a thiazide diuretic is the drug of first choice. Spironolactone at a dose of 1 to 2 mg/kg twice daily will usually produce an obvious diuresis in three to four days. If the ascites is unresponsive or becomes refractory, the addition of frusemide is indicated at a dose rate of 1 to 2 mg/kg twice daily. Overzealous use of frusemide can lead to severe dehydration and hypokalaemia, which will potentiate hepatic encephalopathy.

Abdominal paracentesis is rarely indicated in the management of ascites except for diagnostic purposes. Complete drainage carries the risk of hypotensive shock, protein loss, renal failure and peritonitis. It may be necessary, however, to remove some fluid by paracentesis in order to relieve respiratory distress or abdominal discomfort.
Management of gastric ulceration

Remember bleeding ulcers will worsen hepatic encephalopathy. **Sucralphate** is the mainstay of treatment (and should also be used prophylactically if any animal with portal hypertension is put on steroids). Sucralfate has a number of beneficial effects in ulceration:

- Provides a physical barrier to acid and enzymes at the ulcer site
- Increases mucus output and viscosity
- Increases gastroduodenal bicarbonate production
- Binds bile acids, acid and pepsin
- Promotes epithelial repair

**Antacids** such as H₂ receptor blockers may also be used. However, it has been suggested that you check gastric pH before using these drugs as gastric pH is often high in liver disease. Avoid cimetidine because of its inhibition of the hepatic P450 enzymes. Use ranitidine or famotidine.
Portosystemic Shunts: Why do they seizure and what can we do about it?

Dr. Victoria Doyle

Unfortunately, not only is the exact pathogenesis of hepatic encephalopathy (HE) unknown but there have been no pre-operative factors which can definitively predict which patients are more likely to have post operative seizures. The current veterinary literature is littered with small case series of patients with congenital portosystemic shunts (PSS), treated with different surgical techniques, which attempt to draw conclusions however; most of the reports are conflicting. Speculation exists as to whether the patients age at the time of surgery; the type of portosystemic shunt (intra vs. extra hepatic); pre-operative medical stabilization; pre treatment with phenobarbitone; portovenogram grade or the type of surgery (full ligation, partial ligation or gradual ligation) impact the post operative seizure rate.

Pathogenesis

In a recent review of HE a ‘two-hit hypothesis’ was proposed to explain the pathogenesis of HE. The ‘initial hit’ is the liver dysfunction which leads to hyperammonemia and astrocyte swelling. The ‘second hit’ causes further astrocyte swelling, oxidative stress and rapid deterioration in neurological function. The ‘second hit’ refers to precipitating events including an upper gastrointestinal bleed, systemic inflammation/infection, dehydration, hyponatraemia or administration of drugs including benzodiazepines.

Prevalence

Preoperative seizures are seen in up to 17% dogs and up to 27% of cats. Reported treatments have included phenobarbitone, potassium bromide and/or diazepam. However, few cases have serum levels of either phenobarbitone or potassium bromide tested to ensure that the patients have therapeutic serum levels this maybe a factor in poor seizure control. Tisdall found that pre-treatment with phenobarbitone prior to surgery did not reduce the post operative neurological signs in dogs with extrahepatic PSS. However, none of the cases that had phenobarbitone serum levels within therapeutic range seized post operatively. The post operative neurological signs included ataxia and depression which can be seen after phenobarbitone loading and unrelated to the surgery. However, 2/31 dogs have more severe ataxia and disorientation episodes post surgery and so may not be related to phenobarbitone administration. One of the potential mechanisms of action of phenobarbitone is increased neuronal responsiveness to GABA. There is high GABAergic tone in patients with HE and so phenobarbitone could cause an exacerbation of the signs of HE. Phenobarbitone is also 100% hepatically metabolised and therefore in patients with reduced hepatic function the
metabolism maybe prolonged and it will put additional demands on the liver.

Although the exact post operative seizure rate is variable most studies have a post operative seizure rate of 5% in dogs. In many reports the patients that seizure post operatively are not always the ones that seizure preoperatively which makes predicting post-operative seizures more problematic. There is an argument that the severity of the seizures can be so extreme with many causes becoming refractory to diazepam, phenobarbitone and propofol that patients should be pretreated with anti-convulsants. Uncontrolled seizures are often account for a significant part of the overall mortality rate. However, if all cases were pre-treated with anti-convulsants then approximately 95% of cases will receive additional medication which they do not need. Most drugs will have some degree of side effect and financial cost which must be taken into account.

Reported Treatments

Even recent veterinary studies advocate the use of low protein diets in the medical management of HE in PSS patients. The protein requirement in dogs with experimentally induced PSS has been shown to be the same as in normal dogs. Dogs receiving significant protein restriction (11% crude protein) are likely to develop hypoalbuminaemia and reduced total protein. This is likely to be detrimental to the patient, not least because albumin is an endotoxin scavenger. In fact albumin dialysis has been shown to be beneficial in humans with HE. In patients with chronic liver disease ammonia is metabolised by other organs including skeletal muscle. The loss of muscle may precipitate HE by reducing the amount of ammonia which can be detoxified in the muscle so more ammonia reaches the brain. Vegetable and diary protein are better tolerated in humans and animals with liver dysfunction and so could be used to supplement the diet. Experimental work on germ free dogs with experimentally induced PSS showed the presence of hyperammonemia which suggests that bacteria in the gut cannot be solely responsible for generation of hyperammonemia in patients with HE. Small intestinal enterocytes utilise glutamine, an amino acid found in a variety of high protein foods, as an energy source. Glutamine and water is converted into glutamate and ammonia by the activity of glutaminase. Shawcross showed that the main source of ammonia in portal blood was glutaminase activity from the enterocytes. After feeding the metabolic activity of the small intestinal enterocytes increases, therefore the activity of glutaminase increases leading to post prandial HE.

The use of lactulose, a non absorbable disaccharide to increase gastrointestinal transit time to reduce absorption of glutamine which reduces the production and absorption of ammonia; to acidify colonic pH causing trapping of ammonium ions in the gut; altering colonic flora and it may also have an anti-endotoxic effect. A recent systematic review of high quality human studies into the use of lactulose in HE patients could not find that it
had a significant effect on mortality or on the severity of encephalopathy and therefore could not recommend its use\textsuperscript{24}. There is a requirement in veterinary medicine for placebo controlled trials as to whether lactulose of is benefit or not. Excessive doses of lactulose can cause dehydration, hypokalaemia and hypernatraemia through diarrhoea and vomiting which may precipitate HE\textsuperscript{12,23}.

Studies in humans support the use of minimally-absorbed antibiotics (i.e. Rifaximin) in the medical management of HE as patients receiving this drug had a prolonged remission of HE\textsuperscript{25}. Neomycin inhibits mucosal glutaminase activity and inhibits urease producing coliform bacteria in the gut\textsuperscript{19}. However, due to problems with nephro and ototoxicity its use has fallen out of favour in both human and veterinary medicine. Ampicillin and metronidazole are now more frequently used in veterinary medicine. However, metronidazole can be neurotoxic in both dogs and cats. Cats will typically show forebrain and cerebellar signs where as dogs will tend to show central vestibular signs\textsuperscript{26}. The dose and then length of administration required to cause toxicity is variable. The clinician must remain aware of the possibility that the neurological signs shown in patients with HE receiving metronidazole could in fact be toxic side effects of metronidazole not the HE. Animals exhibiting marked vestibular signs can be confused with seizure activity.

**Anti-convulsant Drugs**

The benzodiazepine diazepam given per os or intravenously is reported in cats and dogs. Cats can develop an idiosyncratic liver failure to the oral formulation of diazepam and so its use is not recommended\textsuperscript{27}. Diazepam has previously been considered to be a good anti-convulsant choice as it has been speculated that the reason why animal’s seizure post operatively is the abrupt reduction in endogenous benzodiazepines\textsuperscript{28}. Therefore, administering a benzodiazepine (i.e. diazepam or midazolam) seems intuitive. Unfortunately, many of the signs seen with hepatic encephalopathy are due to an increase in GABAergic tone\textsuperscript{29}. Benzodiazepines are GABA agonists and therefore there use is likely to precipitate HE\textsuperscript{12}. Benzodiazepines are also primarily metabolised by the liver and so will place additional strain on the liver in patients with reduced hepatic function. The majority of post operative seizures are not responsive to benzodiazepines\textsuperscript{4,6,14}. There is also a lack of clinical repose in dogs given the benzodiazepine antagonist, Flumazenil\textsuperscript{29}. It is therefore unlikely that the mechanism for post-operative seizures is due to the sudden withdrawal of endogenous benzodiazepines.

Potassium bromide is not recommended for use in cats due to the high occurrence of respiratory problems including allergic bronchial disease\textsuperscript{30}. A maintenance dose of 40mg/kg/day of potassium bromide in dogs will take up to 12 weeks to achieve therapeutic serum levels\textsuperscript{31}. Therefore, it is unlikely that this will be an effective anti-convulsant for the majority of cases unless it is given for three months prior to surgery. Patients can receive a loading dose
of 800mg/kg of potassium bromide over 24 hours. However, his needs to be
given either orally or rectally as there is no intravenous formulation. This
loading regime will invariably cause vomiting and diarrhoea which is likely to
precipitate signs of HE by dehydrating the patient and disrupting the
electrolytes. Potassium bromide loading is therefore not recommended in
these patients.

Gabapentin is predominantly renally excreted however it does have some
hepatic metabolism. It has also been suggested for use to control post
operative seizures. However, Gabapentin has moderate anti-convulsant
properties as an “add on” anti-convulsant in dogs. Currently there is only
anecdotal evidence of its beneficial effect in cats. Therefore, it may not be
effective as a sole treatment.

Levetiracetam, is predominantly excreted unchanged via the kidneys however
10-20% is metabolised in serum and other organs. There is no hepatic
metabolism. It is an effective “add on” anti-epileptic medication which is
very well tolerated with minimal side effects in both dogs and cats. The
side effects have been reported to be equal to that of the placebo in humans.
Unfortunately there are currently no veterinary studies on the use of
levetiracetam as a sole therapy. However, anecdotally it appears to be
effective. In dogs levetiracetam will achieve therapeutic levels within 0.6 hours
after oral dosing. Therefore, levetiracetam could be used to control pre-
operative seizures and post-operative seizures. Lipscomb found that the
probability of post operative seizures in cats decreased with increasing
portovenogram grade. Most seizures that occur in the post operative period
occur between 12-72 hours after surgery. Therefore, it maybe possible to
start anti-convulsant medication to those cats with a low portovenogram grade
immediately post operatively. If the portovenogram grade was to be used to
determine which cats received anti-convulsants then the drug would need to
be able to achieve therapeutic levels in a very short period of time. There is an
intravenous and oral formulation of levetiracetam for ease of administration
and the onset of therapeutic levels in this drug is rapid (0.6 hours in dogs) in
comparison to phenobarbitone or potassium bromide. Lee also found that
the dogs with a higher portovenogram grade were less likely to have post
operative seizures and this strategy may also be effective in these patients.
Some cases present with seizures several months after surgery and these
maybe due to continued HE from a residual congenital PSS or acquired PSS.

Continuous rate infusions of propofol can potentially be used successfully to
control episodes of status epilepticus in veterinary patients who seizure after
portosystemic shunt ligation. Propofol is thought to have a GABA effect at a
site distant to the benzodiazepine receptor. Propofol may also have
proepileptogenic effects. It is possible that only the paddling movements are
stopped by the propofol rather than the seizure activity. Therefore, this
maybe the reason why not all cases treated with propofol infusions had a
good clinical outcome. Continuous seizure activity can cause cytotoxic
oedema, raised intracranial pressure and subtentorial/foramen magnum herniation. Seizures may also cause cortical necrosis, polioencephalomalacia and hippocampal sclerosis which may account for the post seizure neurological abnormalities or persistent refractory epilepsy. The use of electroencephalogram (EEG) in these patients would ensure that all seizure activity was stopped. Concomitant treatment with an anticonvulsant (i.e. levetiracetam) would be recommended as well as careful monitoring for signs of raised intracranial pressure.

Significant increases in CSF Quinolinic acid concentration has been found in dogs with portosystemic shunts. Quinolinate is an NMDA receptor agonist and its activation of the receptor can cause irreversible neuronal damage. McDonald showed that the developing rat brain is more susceptible to damage by NMDA receptor activation. With increasing duration of status epilepticus there is a loss of GABAergic inhibition and an increase in excitatory NMDA receptors. Ketamine is an NMDA receptor antagonist and there is a potential role for a ketamine infusion to treat refractory status epilepticus and this maybe utilised in PSS patients. NMDA receptor activation dose not occur immediately and therefore the use of NMDA receptor antagonists are only going to be beneficial in prolonged status epilepticus. Ketamine may also have some neuroprotective effects in rodent models when it is given prior to the induction of status epilepticus or when it is administered up to 90 minutes after the onset of status epilepticus. However, Plumb lists seizures as a potential side effect of ketamine at therapeutic doses in cats. Prolonged infusions of ketamine can cause neurotoxicity in humans and rats.

Figure 1 is a suggested flow diagram management of post operative neurological complications.

Figure 2 is a flow diagram for supportive care for patients in status epilepticus.
Check hydration and electrolyes
- Hypo/hypernatraemia
- Hypokalameia
- Hypoglycaemia
- Dehydration

Check venous ammonia level

Disturbance identified

Elevated (above 75µmol/l)

Correct Disturbance using IV fluid therapy and supplementation

Continue to monitor neurological signs.

Is the patient seizing?

Levetiracetam 20-60mg/kg iv

Stopped?

Yes

No

Levetiracetam 20mg/kg every 8 hours iv/po

Propofol bolus 4-8mg/kg then CRI 6-12mg/kg/hr & continue levetiracetam 20mg/kg every 8 hours iv

Stopped?

Yes

No

Taper dose of propofol by 25% every 2 hours to effect

Consider a ketamine infusion Bolus 5mg/kg then 5mg/kg/hr CRI
**Status Epilepticus**

### Airway / Breathing
- **Yes**
  - Spontaneous breathing
  - Supplement with 100% flow by oxygen
  - Place a pulse oximeter to measure SpO₂
  - Monitor arterial blood gas
  - Consider artificial ventilation if respiratory acidosis or is SpO₂ falls

- **No**
  - IPPV or Ventilatory-short term hyperventilation to PaCO₂ 30mmHg however long term will cause vasoconstriction and reduced oxygen supply to brain

### Circulation
- Intravenous fluid therapy – maintain mean arterial blood pressure 80-100mmHg to maintain cerebral perfusion
- Electrolytes - try to correct any disturbances
- ECG – prolonged seizures can cause myocardial damage and arrhythmias up to 72 hours post seizure
- No compression of the jugular veins as this will increase intracranial pressure
- Elevate head - not greater than 30º or it will reduce cerebral blood pressure
- Monitor for signs of raised intracranial pressure - Bradycardia+hypertension = Cushing's Reflex - Cranial nerve examination-menace response, PLR, oculovestibular, pupil size

### Temperature
- Hyperthermia - actively cool the patient to prevent rhabdomyolysis and acute renal failure. Stop cooling when rectal temperature 38.5°C
- Hyperthermia
- Intravenous fluid therapy
- Maintain mean arterial blood pressure 80-100mmHg
- Electrolytes - try to correct any disturbances
- ECG – prolonged seizures can cause myocardial damage and arrhythmias up to 72 hours post seizure
- No compression of the jugular veins as this will increase intracranial pressure
- Elevate head - not greater than 30º or it will reduce cerebral blood pressure
- Monitor for signs of raised intracranial pressure - Bradycardia+hypertension = Cushing's Reflex - Cranial nerve examination-menace response, PLR, oculovestibular, pupil size

**Treat with mannitol 0.2g/kg over 15 mins iv or hypertonic saline 3mg/kg over 15 mins**
Dose can be repeated by monitor for electrolyte disturbances and dehydration
Relevant Information from Human Medicine

The pathogenesis of HE in humans and experimental animals has been recently reviewed. Hyperammonaemia secondary to liver dysfunction is still thought to be the primary mechanism of HE. However, the level of arterial ammonia does not necessarily correlate with degree of HE in people with cirrhosis or in animals with PSS; therefore, other trigger factors must play a role. There is increasing evidence that inflammation, infection, oxidative/nitrosative stress can modulate the effect of ammonia on astrocyte function.

In humans with chronic liver disease and minimal HE (portocaval shunted rats are a good model for this disease process) the degree of hepatic encephalopathy is not related to serum ammonia level but is related to the level of inflammatory markers (C-reactive protein, white blood cell counts and IL-6). The beneficial role of COX inhibitors have been shown in rats with portocaval shunts. Minocycline has been shown to have anti-inflammatory effects; it prevents microglial activation, up regulation of inflammatory cytokines (IL-1β, IL-6 and TNF-α) and reduces oxidative/nitrosative stress which may have a beneficial effect in the degree of HE. There have been no clinical veterinary studies published so far on the use of minocycline to the author’s knowledge.

Approximately 50% of humans with cirrhosis present to hospital because of an infection. The veterinary literature also suggests that a number of cases of PSS are diagnosed with concurrent infections (i.e. urinary tract, GIT especially). Portal hypertension can cause bacterial translocation of bacteria and hence maybe an important consideration for post operative care. Hyperammonemia also impairs neutrophil function which can increase the patient’s susceptibility to infection. Probiotics have been shown to improve liver function, reduce bacterial translocation and increase neutrophil function in humans. There have been no clinical veterinary studies on the use of probiotics in PSS patients to the author’s knowledge.

Hyperammonaemia has been shown to increase oxidative stress by decreasing anti-oxidant levels, increasing free radial production and increasing lipid peroxidation. N-AcetylCysteine an antioxidant many have a beneficial role in humans with cirrhosis. N-AcetylCysteine has been used in cats with paracetamol intoxication but not to the author’s knowledge in PSS patients. S-Adenosyl-methionine (SAMe) is a precursor to glutathione and has an important role for detoxification and protecting the cells against oxidative damage. SAMe has been shown to support liver function in dogs with vacuolar hepatopathy. However, there are currently no studies into its use in veterinary patients with PSS to the authors knowledge.

Ammonia and manganese are thought to increase the production of neurosteroids which cause an increase GABAergic tone and can precipitate HE in humans and experimental models. Manganese is also directly neurotoxic and can increase the production of Alzheimer type II cells in the
A recent study in dogs with congenital portosystemic shunts has shown an increase in serum manganese levels. The role of manganese accumulation in congenital PSS warrants further investigation as specific chelation therapy could be used to treat PSS patients with HE.

The Future

There are two main avenues which could be investigated. The first is an alternative approach to medical stabilization prior to surgery which maybe possible by utilising the recent evidence for other factors being involved in patients with HE. The second is judicial use of alternative anti-epileptic drugs which may have a greater beneficial effect in either preventing or managing pre and post operative seizures.

References


Imaging of Portovascular Abnormalities

Dr. Tobias Schwarz

Introduction
Suspected portovascular abnormalities are a major imaging indication in the canine and sometimes feline patient. The confirmation of the presence and nature of a portosystemic anomaly is essential for surgical decision-making. In addition it is desirable to know the exact location, course and number of anomalous vessels. Different imaging modalities have been applied for this purpose with different pros and cons.

Survey radiography
Survey radiography can reveal non-specific signs of a portosystemic shunt, such as microhepatia, Renomegaly, emaciation, pica and urolithiasis, which may be relevant for case management. However it is not possible to determine the presence and exact nature of a shunt.

Mesenteric angiography
This requires a laparatomy and, injection of contrast medium into a mesenteric vein and a timed exposure or continuous fluoroscopic exposure. Mesenteric angiography has served as the gold standard for portovascular imaging for many years. Its main draw back is its invasiveness, time consuming and requires large amounts of contrast medium

Abdominal ultrasound with Doppler or contrast medium
Abdominal ultrasound with colour Doppler application has been developed as an alternative to mesenteric angiography, as a non-invasive diagnostic tool, requiring no general anaesthesia or surgical preparation. In experienced hands it is very accurate for intrahepatic shunt detection and moderately accurate for extrahepatic vascular abnormalities. It requires deep sedation and is still relatively time consuming. Its main draw back is the operator dependency and gastrointestinal gas, inhibiting imaging of deeper structures. Contrast-enhanced ultrasound examination is a new non-invasive way to diagnose the presence of a shunt. Since the liver tissue is continuously scanned during the procedure, this technique allows determination of the presence of a shunt, but not its exact anatomy, if it is located extrahepatically.

Scintigraphy
Per rectum application of unbound Tc$^{99m}$ results in portal uptake of the radioisotope. The presence of a shunt can be accurately determined by comparing the temporal uptake of liver a and heart. The shunt anatomy can however usually not be determined with certainty.
An alternative radioisotope application is a splenic injection under ultrasound guidance.

**Abdominal vascular CT**

Abdominal computed tomography (CT) is gaining popularity in veterinary practice with the newer generation of multislice CT scanners. With these scanners it is possible to obtain thin slice images of the entire abdomen within 30 seconds or less. Use of contrast medium is essential for these to demonstrate vascular detail. Because of the high sensitivity of CT, contrast medium can still be detected after haemodilution in the pulmonary and systemic capillary bed. Therefore only a peripheral injection of contrast medium is required and all caval and portal abnormalities can be detected. The procedure requires general anaesthesia and depending on the scanner type, takes 20 to 30 min in total to perform. The main disadvantage of CT is the need for accurate timing of the contrast series, which can be difficult.

**Requirements:**
- General anaesthesia
- Power injector (= injection pump), catheter in cephalic vein
- Respiration control

**Technique:**
- Timed contrast medium injection & scan start (test bolus, guess, bolus tracking)
- Inject low concentration i.v. contrast medium (240 mg Iodine / ml) @ 800 mg Iodine / kg
- Arterial, portal and/or caval venous phase image series

**Duration:**
- 30 min

**Applications:**
- Portosystemic shunts (intra- / extrahepatic, single / multiple)
- Caval abnormalities (adrenal mass compression / invasion, segmental aplasia)
- Vascular thrombosis (aortic, portal, caval)
- Vascular anatomy (renal donor screening)
- Tumour vascularity & vascular trauma

**Multi-phased time-resolved contrast enhanced MRA**

Magnetic resonance angiography is a relatively new application to image the abdominal vasculature. Use of Gadolinium based contrast media improves visibility of vascular detail. Imaging series are acquired over approximately 60 seconds. The main advantage of this method is that there is no bolus specific timing involved; images are acquired continuously after contrast medium injection.
Conclusions:

Diagnostic imaging provides many options for the diagnosis of portosystemic abnormalities. Ultrasound is widely available and can be very successful in experienced hands. CTA and MRA are new, minimally invasive imaging modalities for the diagnosis of portosystemic shunts.

Further reading:


Surgical Treatment of Extrahepatic Portosystemic Shunts – What is the Evidence Base?

Mickey Tivers

Introduction

Over the last 10 years there has been growing interest throughout the veterinary profession regarding the use of Evidence Based Medicine (EBM). There are a number of definitions of EBM but it is often described as “the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients” (1). It is important to remember that in practice this means that we should take the best available evidence and integrate this with our own clinical expertise and the needs of the patient in order to make appropriate clinical decisions. Several papers have reported the application of EBM in the veterinary field with examples including the management of cruciate disease, chronic kidney disease and emesis in the dog (2-4). The practice of EBM is designed to maximise decision-making in a given situation and is therefore relevant to us all. Nevertheless, in general, there remains a lack of a decent evidence base for many aspects of veterinary medicine.

Evidence based medicine relies on five well-defined steps (5).

The first step is “Asking focused questions”. In order for the question to be of benefit to clinicians and their patients the question must be relevant to the patients’ problems and directed towards searching for relevant and precise answers.

The next step is “Finding the evidence”. This is the process of gathering data relevant to your question. It is important to find the “best” evidence available. In most instances this will involve searching PubMed and other internet search engines for key words relating to your question.

The third step is “Critical appraisal”. All evidence is important when using an outcomes-based approach. However, not all evidence is equal and we must take into account the validity, results, impact, power, relevance and applicability when assessing it. Thus our interpretation and use of evidence is very important for our patient care. There are a number of published systems for grading studies in terms of the quality of evidence. Below is a modification of a published grading system from the Oxford Centre for Evidence Based Medicine (Table 1) (5). When we are considering the effects of a therapy we are often presented with a study comparing the treatment with a pre-existing treatment. The evidence gained from such a study relies on whether patients were randomly allocated to treatment groups, whether the assessors were blinded, whether the treatment groups were similar, whether the follow up sufficient and whether groups were treated equally apart from the
there are several difficulties encountered when applying EBM to surgical as opposed to medical treatment. Surgery can be highly operator dependent and there can be a steep learning curve associated with a given technique. These factors should be taken into account when interpreting evidence, as a given technique may not have the same results at a different institution. As outlined in Table 1, randomised, blinded placebo controlled trials provide the highest level of evidence. However, there are ethical problems with introducing a placebo control for surgical diseases and therefore surgical studies are more likely to compare two treatments rather than a treatment and a placebo.

The fourth step is “Making a decision”. This involves the integration of the evidence into our clinical decision-making based on its relevance. In order to do this we need to consider the validity of the evidence in terms of how the trial corresponds to our population of patients and how feasible the treatment is in our clinical setting. We must also assess how reliable the results are based on the methodology used in the study.

The final step is “Evaluating performance”. This involves assessing our effectiveness in carrying out steps 1-4 and seeking ways to improve them in the future.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>1a</td>
<td>Systematic review of randomised controlled trials (RCT)</td>
</tr>
<tr>
<td>1b</td>
<td>Individual RCT</td>
</tr>
<tr>
<td>2a</td>
<td>Systematic review of cohort studies*</td>
</tr>
<tr>
<td>2b</td>
<td>Individual cohort study (low quality RCT)</td>
</tr>
<tr>
<td>3a</td>
<td>Systematic review of case control studies#</td>
</tr>
<tr>
<td>3b</td>
<td>Individual case control study</td>
</tr>
<tr>
<td>4</td>
<td>Case series (and poor quality cohort and case control studies)</td>
</tr>
<tr>
<td>5</td>
<td>Expert opinion without explicit critical appraisal, or based on physiology, bench research or “first principles”</td>
</tr>
</tbody>
</table>

* A cohort study follows a group over a period of time and investigates the effect of a treatment or risk factor
# A case control study is one that examines the effect of a risk factor on the outcome for a group of subjects with a disease compared to that of a matched control group without the disease

**Establishing the evidence base for the treatment of extrahepatic shunts**

Congenital portosystemic shunts (CPSS) have been reported in the veterinary literature with increasing frequency since 1974 (6). A variety of treatment options have been recommended for the management of CPSS and these include medical management and various forms of surgical attenuation (7-13). The aim of this review is to examine the evidence base for the management of
extrahepatic CPSS in dogs with a view to identifying whether one treatment method can be recommended over another. The first step was to determine the question that we wanted to answer. The question was “Which treatment offers the best short term and long term outcome for dogs with extrahepatic CPSS and is that treatment superior to the others”.

An extensive literature search had been performed in October / November 2009 as part of another project and a database of papers concerning all aspects of CPSS in dogs had been made. This database had been kept up to date since it was created. The database was searched for relevant original papers reporting the short and / or long-term outcome of dogs treated for CPSS. Thirty-three articles were identified as providing relevant information for answering the question. Thirty-one of the articles were classified as grade 4 with the remaining two classified as grade 5. None of the articles were graded higher than 4. As the vast majority of articles were graded as 4 it was decided to attempt to divide the grade further (Table 2).

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>4a</td>
<td>Poor quality prospective cohort and case controlled studies</td>
</tr>
<tr>
<td>4b</td>
<td>Retrospective cohort study</td>
</tr>
<tr>
<td>4c</td>
<td>Case series – describing outcome for one technique</td>
</tr>
<tr>
<td>4d</td>
<td>Case series – describing novel aspect of management and providing some information regarding outcome</td>
</tr>
<tr>
<td>4e</td>
<td>Poor quality case series – concerns regarding study design and / or ability to interpret information</td>
</tr>
</tbody>
</table>

Table 2: Modification to grade 4 evidence

**Medical versus surgical management**

Four articles compared medical treatment with one or more type of surgical treatment (12, 14-16). One of these studies was a prospective cohort study, comparing medical management versus a variety of surgical treatments with a relatively large number of cases (99 surgical and 27 medical). The dogs were followed for between 15 and 1,642 days. The results of this study indicated that dogs treated surgically survived significantly longer than those which were managed medically. Twenty nine point six percent of medically managed dogs died during the study period compared with 10.1% of surgically treated dogs. Although this study was prospective it was not randomised or blinded and this meant that was therefore categorised as grade 4a.

Two studies focused on reporting the outcomes of surgical management but also included information on a small number of dogs managed medically (12, 14). Both studies described very small numbers of medically managed dogs and little relevant information could be gained so both were graded 4e.

Another study compared medical and surgical management but the details and information given in the report are incomplete and it was given a grade of 5 (16).

One additional paper presented a case series of medically managed dogs,
including nine with extrahepatic shunts (17). Three dogs were euthanased with a mean survival of 8.5 months but the remaining dogs had survived for a mean of 79.3 months. This paper was graded 4c.

Thus the evidence base for medical versus surgical management of extrahepatic CPSS in dogs is very low with a small number of studies of low grade and small case numbers. The Greenhalgh paper (15) provides the highest level of evidence and reports a reasonable number of cases. This evidence would support the use of surgical management over medical treatment although it is still weak (grade 4a).

**Comparison of surgical attenuation**

Four studies compared suture ligation with ameroid constrictors (14, 18-20). The first paper was a retrospective study comparing the short and long term outcome of suture ligation in 12 dogs and ameroid constrictor placement in 10 dogs (18). There was no mortality in either group and although there were more postoperative complications in the suture group this difference was not significant. There was no statistically significant difference between the two groups for long term outcome as assessed by clinical rating score, serum bile acids and scintigraphy. This study was graded 4b. The second paper was a retrospective study comparing the short-term outcome of 20 dogs with suture ligation and 10 dogs with ameroid constrictor placement (19). Mortality was 15% for the suture group and 10% for the ameroid group. There was no significant difference in mortality or postoperative complication rates between the two groups. However, this study did find that surgery time was statistically significantly faster for the ameroid group. This study was graded 4b. The third paper compared the short and long term outcome between suture ligation in 29 dogs and ameroid constrictor placement in 16 dogs (14). There was no statistically significant difference in the mortality rate between the two groups (10.3% for the suture group and 6.3% for the ameroid group). There was no statistically significant difference in long-term outcome between the two groups in terms of complications. This study was graded 4b. The fourth paper was a review article which described some details of the outcome for a group of dogs treated with suture ligation and a group treated with ameroid constrictors (20). As the information given was not complete this study was grade 5.

Three grade 4b papers compared the outcomes between suture ligation and ameroid constrictor placement. This evidence is weak and based on small numbers; however, this is more robust than the evidence for many other aspects of the management of CPSS. On the basis of this we would conclude that there is not sufficient evidence to recommend the use of suture ligation over ameroid constrictor placement and vice versa. No studies have compared suture ligation or ameroid constrictor placement with cellophane banding.

**Case series reporting short and / or long term outcome**

Many of the papers included in this review are simple retrospective (or
occasionally prospective) case series reporting the short and / or long term outcome of a given surgical technique. Eleven papers reported case series of dogs treated with suture ligation which specifically looked at short and / or long term outcome (12, 13, 21-29). Two papers were considered to be grade 4e due to an inability to fully interpret the results (12, 28). The other nine papers were considered to be 4c grade (13, 21-27, 29). Two papers report case series of dogs treated with ameroid constrictors, assessing short term and long term outcome (9, 10). Both studies were graded 4c. Two papers report case series of dogs treated with cellophane banding (8, 11). Both of these studies were graded 4c. These studies are all case series with no comparison or control group. As such they represent relatively low evidence with the majority grade 4c. Whilst we can use these studies to justify the use of a given technique they do not provide sufficient evidence to allow us to decide if one treatment is superior to another. There is an extremely wide variation in almost all aspects of these reports, particularly in terms of classification of mortality and complications. Long-term follow up varies considerably both in terms of duration but also in methods of assessment, i.e. clinical assessment, biochemical testing, ultrasonography, scintigraphy. The lack of consistency between reports makes direct comparison unhelpful. In order to allow fair comparisons between these reports we would need them to use the same outcome measure which had been proven to be valid. Reports also span a large time frame from 1987 to 2005. Other factors such as anaesthetic and postoperative care and greater familiarity with case management may have affected the results during this time period although this remains unproven.

Other case series
Eleven other studies were identified that whilst reporting case series of dogs treated for CPSS did not specifically address short or long term outcome. Nevertheless some of these studies do report outcome, often in the form of postoperative mortality rate. As the main focus of the study was not outcome these papers do not provide as high a level of evidence as those that set out to specifically evaluate outcome (30-40). These studies have therefore been graded 4d.

Conclusions
It probably doesn’t come as much surprise to the reader that the available evidence base for the treatment of extrahepatic CPSS is rather weak. We did not identify any grade 1, 2 or 3 studies which is unfortunate as these provide the best information for clinicians to make an informed choice regarding treatment. The majority of studies fell into grade 4 and this provides relatively weak information for differentiating between treatments. Thus there is a lack of strong evidence to support the use of one surgical technique over another. It is probably fair to say that the available evidence would support surgical treatment over medical management but this is still very weak.
The Way Forward

There is a distinct lack of prospective cohort studies looking at the outcomes of different treatment options for extrahepatic CPSS in the veterinary literature. One of the major problems that also needs addressing is the subject of outcome. Possible outcome measures for CPSS include short-term information such as peri-operative mortality and complications and long-term data focusing on recurrence, quality of life (QOL) and survival. Ideally objective measures should be used such as serum bile acids, ultrasound, scintigraphy and contrast computed tomography.

As stated in the introduction we should be trying to adopt an evidence-based approach in order to maximise our patient care. It is clear that for the treatment of extrahepatic CPSS (as in many other areas of veterinary medicine) there is a lack of convincing evidence to recommend any one treatment over another. We therefore integrate the existing knowledge with our own clinical experience and the needs of the animal to recommend best treatment. In practice this means that if you are having good success with a given treatment then that should be your standard of care. However, as individuals and a community we must try hard to improve the quality of research and hence the evidence base available.

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12. Johnson CA, Armstrong PJ, Hauptman JG. Congenital portosystemic shunts in dogs:


Congenital Portosystemic Shunts in Cats

Vicky Lipscomb

Introduction

Firstly, thank you to Mickey Tivers – with kind permission these notes are largely a very edited version of a much more comprehensive literature review that he has produced for his PhD.

Congenital portosystemic shunts (CPSS) are less common in cats compared to dogs, with a reported incidence of 2.5 per 10,000 cats treated in referral practice (1).

In cats the most common shunt is an extrahepatic abnormal vessel connecting the left gastric vein to the caudal vena cava (6, 7, 10, 12). The majority of intrahepatic CPSS in cats are left divisional, usually a patent ductus venosus (PDV) (13, 14).

Signalment

Similar to dogs, cats typically present young (<6 months) but may be mature (up to 10yrs reported). The majority of cats are domestic shorthair, although pedigree breeds reported with CPSS include the Persian, Himalayan and Siamese.

Clinical signs associated with CPSS in cats are extremely variable and can be intermittent. The vast majority of cats (93-100%) present with some degree of neurological abnormality (3, 6-8). Unusual features of CPSS in cats compared to dogs include ptyalism (hypersalivation) and copper coloured irises (7, 8, 11, 12). Other clinical signs include gastrointestinal signs, urinary tract signs and polyuria/polydipsia (1, 6-8) but these are not as commonly seen in cats compared to dogs.

Diagnostic Tests

Biochemistry and haematological changes are typically mild. Compared to dogs, decreased albumin, total protein, hypoglycaemia and anaemia are less common. Clotting abnormalities have described in dogs with CPSS but there have not been any studies examining this in the cat.

Fasting ammonia is increased in the majority of cats with CPSS (2, 5, 7, 9, 11, 16) but can occasionally be normal (4, 5, 7, 16). The sensitivity and specificity of ammonia for the diagnosis of CPSS in cats has been reported as 83% and 86% (16).

A bile acid stimulation test is the most accurate test to measure liver function and the sensitivity of preprandial and postprandial bile acids in cats has been reported as 58-100% and 100% respectively with a specificity of 84% for fasting bile acids (1, 7, 11, 16, 17).

Imaging
Although surgery may allow the direct diagnosis of a CPSS, some form of pre-operative imaging is desirable in order to confirm the diagnosis and acquire further information regarding the nature of the shunt to help with surgical planning - see earlier lecture on imaging of portosystemic abnormalities.

**Medical Management**

Many cats with a CPSS show relatively severe clinical signs at the time of diagnosis and it is important to stabilise their condition with medical management prior to definitive treatment. In one study of 25 cats managed medically prior to surgery there was no response to medical treatment in 12%, a partial response in 56% and 32% of cats had complete resolution of their clinical signs (6). Whilst it is clear that medical management may be effective in stabilising the clinical signs associated with HE in the short term there is very little information regarding its use as sole treatment long term in the cat.

**Surgical Management**

Surgery is the recommended treatment for most cats with CPSS. A number of different surgical procedures have been described for the management of CPSS in cats, including suture attenuation, ameroid constrictor and cellophane band. Making a decision between different techniques is made more difficult by the limited availability of evidence supporting one technique over another. An alternative to surgical management is coil embolisation using interventional radiology which has been described in one cat with an intrahepatic CPSS (27).

**Suture attenuation**

Full ligation has been reported to be possible in 29-43% of cats (1,3,6,8,10,19). A study of six cats with intrahepatic CPSS found that only one (17%) of the cats could tolerate a full attenuation (14). However, a larger study did not detect a significant difference in the proportion of complete attenuation between intrahepatic and extrahepatic CPSS (8). There is little information on acceptable increases in portal pressures published for the cat. Normal portal pressures in cats with CPSS have been reported as 3-13mmHg or 0-14cmH₂O (5-7,14,19). It would seem sensible to limit increase in portal pressures following CPSS attenuation in cats to no greater than a 10cmH₂O (8mmHg) increase or doubling from the pre-occlusion value and not exceeding 20-23cmH₂O (15-18mmHg) total, based on values extrapolated from the information available in the cat and those reported for clinical use in dogs (3,14, 15,19-22).

Several studies have shown that cats with complete CPSS attenuation have a better long term outcome than those treated with partial attenuation. Cats treated with partial attenuation had a high frequency of relapse of clinical signs which are usually attributable to persistent shunting but may also be due to the development of multiple acquired shunts (1,3,9,19,23). However, some cats can have a good outcome following partial attenuation (2, 14, 23). A
second surgery performed two to three months later allows a further attempt at complete suture attenuation (18,23). During this time the hepatic vasculature will have developed, allowing full attenuation in the majority of cats (1,6, 8,19). A study comparing portovenography at first and second surgery in cats confirmed that the degree of opacification of intrahepatic vessels increased significantly between surgeries and that the degree of vascular development at first surgery was correlated with the risk of developing postoperative neurological complications (6).

**Ameroid Constrictor**

Long term residual shunting is common with both AR and CB techniques and the exact rate of attenuation is unknown. Cats with a very high initial portal pressure (e.g. >25mmHg) following temporary CPSS occlusion may not be good candidates for an AC due to the risk of development of multiple acquired shunts if the rate of shunt attenuation exceeds the capacity of the intrahepatic portal vasculature to accommodate the acute increase in blood flow (18). It is still important to perform close postoperative monitoring as it is possible for acute portal hypertension to develop if an AC shifts position acutely occluding the CPSS, or if acute thrombus formation in the CPSS occurs.

**Cellophane Band**

Although some surgeons place a CB around a CPSS without any initial shunt attenuation, others recommend measuring portal pressure and performing temporary complete CPSS occlusion in all cases so that any cat that can tolerate a complete acute CPSS attenuation can benefit from this. There is very little information on the use of CB in cats as yet.

**Intrahepatic shunts**

In one study of six cats with intrahepatic CPSS it was possible to attenuate the vessel directly either post-hepatically in cats with left divisional CPSS or via intrahepatic dissection in right or central divisional CPSS, without the need for more complicated intravascular techniques (14). An anatomical study in cats concluded that PDVs can be readily ligated in a prehepatic location where the vessel enters an ampulla prior to the caudal vena cava (25). One report described the successful use of an ameroid constrictor on a Siamese cat with a right divisional intrahepatic CPSS but it is generally more difficult to apply either an AC or CB to an intrahepatic shunt (26).

**Surgical Complications** (see outcome table)

Neurological problems are the most common postoperative complication in cats and are reported in 13.3-37% (7-9, 24) compared to 0-20.6% in dogs. Seizures are a particularly severe complication, reported in 6.5-22.4% of cats treated with suture attenuation (1, 8,9,14). Interestingly, neurological complications still occur following treatment with gradual occlusion devices (7,11). Some cats (4-13.3%) die or are euthanased due to their
neurological complications (8,9,11), whilst other cats may never fully recover or require long term anti-seizure medication. Despite this, many cats can still make a full recovery with 56% having complete resolution of neurological signs and a further 22% having a good quality of life with medical management of their neurological signs (8). One study identified that cats with poor development of their intrahepatic vasculature on intra-operative portovenography had an increased risk of developing postoperative neurological complications (6). However, no other risk factors have been identified and there does not seem to be a difference between intrahepatic and extrahepatic CPSS, full or partial ligation, the age of the cat or the presence of seizures pre-operatively (8).

Prophylactic treatment of cats with phenobarbitone has been suggested to reduce the risk of postoperative seizures. Little information is available to support this concept in the cat. In one study neurological complications still occurred despite 83% of cats receiving preoperative anti-seizure medication (11). Close monitoring of cats for neurological signs in the postoperative period is recommended, with anti-seizure medication being given promptly if any neurological signs are detected, even if relatively mild.

With improvements in anaesthesia, critical care and surgical experience, the occurrence of portal hypertension has become very rare. Current peri-operative mortality rates are 0-4.5% (suture ligation or ameroid constrictors) (7, 8, 11), with no cats in these studies dying as a result of portal hypertension.

**Outcome** (see outcome table)

Recent data suggests that most cats have a good outcome following surgery which is comparable to outcomes reported for dogs (8). However, all long term outcome data is based on subjective owner assessment. Objective measures such as bile acid testing and scintigraphy have also been used but have only assessed short term outcome (<6 mon) (7, 8, 11, 24).
<table>
<thead>
<tr>
<th>Paper</th>
<th>Number of cats</th>
<th>Method of attenuation</th>
<th>Postoperative neurological complication rate</th>
<th>Mortality rate</th>
<th>Short term outcome</th>
<th>Long term outcome</th>
</tr>
</thead>
</table>
| White 1996 | 6              | Suture (5 partial, 1 full attenuation) | 16.7% 1/6 cats suffered severe neurological complications | 16.7% 1/6 cats died due to neurological complications | -                | Excellent outcome in 4/5 (80%) cats (2-18 months)  
Clinically normal, no medication  
2 cats died or euthanased due to unrelated reasons  
Fair outcome in 1/5 (20%) cat (24 months)  
Required medication to control signs  
Died of unrelated reasons |
| Wolschrijn 2000 | 15            | Suture                | 13.3% 2/15 cats suffered severe neurological complications which resulted in status epilepticus and coma | 20% 3/15 cats died, two due to neurological complications and one euthanased intra-op due to portal vein hypoplasia | -                | -                |
| Havig 2002  | 12             | Ameroid               | 33.3% 4/12 cats suffered neurological complications – however, all had neurological signs before surgery | 0% 0/12 | Repeat examination at 3 months postsurgery  
5/12 (41.7%) clinically normal  
7/12 (58.3%) continued neurological signs | Excellent outcome in 2/9 (22.2%) cats (10-60 months)  
Clinically normal  
Normal shunt fraction  
Good outcome in 1/9 (11.1%) cats (10 months)  
Clinically normal  
Persistent shunting on scintigraphy  
Required medication to control signs  
Fair outcome 2/9 (22.2%) cats (6 months)  
Alive but with progression or recurrence of neurological signs  
Both on medical management  
Poor outcome 4/9 (44.4%) cats (6-36 months)  
Euthanased due to persistence or progression of neurological signs |
<table>
<thead>
<tr>
<th>Study</th>
<th>Cats</th>
<th>Material</th>
<th>Complications</th>
<th>Outcome</th>
<th>Repeat Examination</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyles 2002</td>
<td>23</td>
<td>Ameroid</td>
<td>Up to 77%</td>
<td></td>
<td>4.5%</td>
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<td></td>
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<td>17/22 cats suffered some form of complication including blindness (10), hyperthermia (6), frantic behaviour (5), encephalopathy (5), seizures (3), focal seizures (1), coagulopathy (1), tremors (1), seroma (1) and transfusion reaction (1) – the precise proportion of cats with neurological complications was unclear</td>
<td></td>
<td>1/22 cats died due to status epilepticus</td>
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<tr>
<td>Hunt 2004</td>
<td>5</td>
<td>Cellophane</td>
<td>20%</td>
<td></td>
<td>0%</td>
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<td></td>
<td></td>
<td></td>
<td>1/5 cats suffered mild neurological complications</td>
<td></td>
<td>0/5</td>
<td></td>
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<tr>
<td>Lipscomb 2007</td>
<td>49</td>
<td>Suture</td>
<td>37%</td>
<td></td>
<td>4.1%</td>
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<td></td>
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<td>18/49 cats suffered some form of neurological complication including seizures (11), tremors (8), hyperaesthesia (8), blindness (8), ataxia (8) and depression / weakness (4)</td>
<td></td>
<td>2/49 cats euthanased due to seizures</td>
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<td></td>
<td></td>
<td></td>
<td>Repeat examination 2-2.5 months postsurgery</td>
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<td>Excellent outcome in 15/20 (75%) cats (3-51 months)</td>
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<td></td>
<td></td>
<td></td>
<td>13/14 (92.9%) clinically normal</td>
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<td>Clinically normal</td>
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<td></td>
<td></td>
<td></td>
<td>1/14 (7.1%) cats dull and intermittent seizures</td>
<td></td>
<td>No medication (2 on low protein diet)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>10/14 still on medical management</td>
<td></td>
<td>6 normal shunt fraction</td>
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<td></td>
<td></td>
<td>8/14 (57%) persistent shunting on scintigraphy (3 multiple acquired shunts)</td>
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<td>5 persistent shunting on scintigraphy</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Repeat examination at least 2 months postsurgery</td>
<td></td>
<td>Good outcome 1/20 (5%) cats (41-42 months)</td>
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<td></td>
<td></td>
<td></td>
<td>3/5 (60%) clinically normal, normal liver function test</td>
<td></td>
<td>Occasional episodes of lethargy</td>
<td></td>
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<td></td>
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<td></td>
<td>2/5 (40%) clinically normal, increased ammonia tolerance test</td>
<td></td>
<td>No medical treatment</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>One cat failure of shunt occlusion</td>
<td></td>
<td>Fair outcome 1/20 (5%) cats (41-42 months)</td>
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<td></td>
<td></td>
<td></td>
<td>One cat multiple acquired shunts</td>
<td></td>
<td>Occasional episodes of lethargy</td>
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<td></td>
<td></td>
<td></td>
<td>Repeat examination 0.25-6 months postsurgery</td>
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<td>Poor outcome 3/20 (15%) cats (6-44 months)</td>
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<td></td>
<td></td>
<td></td>
<td>12/36 (33.3%) normal bile acids</td>
<td></td>
<td>Progression of clinical signs</td>
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<td>24/36 (66.6%) abnormal bile acids</td>
<td></td>
<td>One died in status epilepticus</td>
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<td></td>
<td>12/23 (52.2%) normal ammonia</td>
<td></td>
<td>Two euthanised</td>
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<td>11/23 (47.8) abnormal ammonia</td>
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<td></td>
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<td>12/28 cats with partial attenuation had second surgery</td>
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<td></td>
<td>9/12 full attenuation</td>
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<td></td>
<td></td>
<td></td>
<td>2/12 further partial attenuation</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>1/12 multiple acquired shunts</td>
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</table>

Summary of the complications and outcome of surgical management of feline CPSS reported in the literature.
References

Out with the New and In with the Old: Intrahepatic Shunt Surgery

Prof. Dan Brockman

INTRODUCTION:

What, other than economics, drives your decision making regarding therapy for intrahepatic portosystemic shunts? Is it fear, experience, the influence of a valued mentor or colleague, the resources available to you or the desire to achieve the best outcome for your patient? What constitutes the best outcome? What outcome is unacceptable? Do we know which of the therapies are most durable? Death following treatment attempt is an unacceptable outcome for the individual animal and its owners but the mortality rates for surgical manipulation of intrahepatic shunts are not different from reported mortality rates for extrahepatic shunts, when performed by an experienced surgeon. The perfect outcome for any portosystemic shunt therapy is to abolish flow through the shunting vessel such that all portal blood enters the liver and that the liver responds to this increased flow by increasing in mass and functioning normally. The development of multiple acquired shunts following intrahepatic shunt attenuation or residual shunting through the shunt vessel both represent suboptimal outcomes but can still result in improved hepatic blood flow and (subjectively) improved quality of life for the animals and owners. What, then, should we do?

TECHNIQUES

An excellent understanding of the hepatic vascular anatomy and knowledge of the actual location of the shunting vessel (ideally determined by intraoperative mesenteric portography) are extremely helpful. The lack of an accurate and safe method to dissect through the liver has always been a major concern for any would-be shunt surgeon. Left divisional shunts (presumptive patent ductus venosus) are frequently predominantly “outside” the liver parenchyma at the diaphragmatic liver surface and dissecting either the shunting vessel or the hepatic vein it drains into cranial to the liver does not involve a great deal of liver parenchyma dissection. These are the most straightforward of the intrahepatic shunts. Central divisional and right divisional shunts can be a more challenging and potentially dangerous dissection. The high prevalence of this configuration of shunt in Australian Shepherd dogs and led to the development of a portal venotomy approach by Geraldine Hunt, in an attempt to reduce the risk associate with intrahepatic dissection, for these dogs. Other intravascular approaches (caudal caval venotomy) have also been described in an attempt to avoid the apparent risk associated with hepatic parenchymal dissection. The advent of ultrasonic aspirators to facilitate liver dissection was seen as a massive improvement for those who could afford them.
Ultimately, concern about the danger associated with liver dissection led to the development of minimally invasive shunt attenuation techniques. The author has not had the opportunity to use an ultrasonic aspirator and has, for over 20 years of intrahepatic shunt surgery, used a combination of blunt instrument dissection and the unsheathed end of a Poole suction tip to dissect around shunts in all different locations. Although on occasions this technique and these dissections were very challenging, over time, this technique has proved, in the authors hands, to be safe and reliable.

OUTCOMES:

The following is the abstract of a retrospective study recently performed by Mickey Tivers:

**Acute mortality and morbidity rates following intrahepatic versus extrahepatic portosystemic shunt attenuation at first and re-operation surgery**
M. S. Tivers, D. Brodbelt, R. Smithers, V. J. Lipscomb & D. J. Brockman

There were 41 intrahepatic shunts in 35 dogs and 6 cats, and 138 extrahepatic shunts in 108 dogs and 30 cats. Significantly more extrahepatic shunts tolerated complete ligation at the first surgery (61, 44.2%) compared with intrahepatic shunts (8, 19.5%, \(P=0.004\)). There were no fatal intraoperative complications in either group.

Three non-fatal intra-operative complications were reported in the intrahepatic group: iatrogenic pneumothorax (n=2), haemorrhage from shunt (n=1). Five animals (12.2%) in the intrahepatic group died in the immediate postoperative period. Reasons for death or euthanasia included presumed or confirmed gastroduodenal ulceration (n=4) and presumed pulmonary thromboembolism (n=1). Seventeen animals suffered postoperative complications.

One animal in the extrahepatic group suffered non-fatal intra-operative haemorrhage. Eight animals (5.8%) in the extrahepatic group died in the immediate postoperative period. Reasons for death or euthanasia included neurological complications (n=6), postoperative haemorrhage (n=1) and gastrointestinal haemorrhage (n=1). Forty six animals suffered postoperative complications. There was no significant difference in either the mortality or the complication rate between intrahepatic or extrahepatic shunts or between partial or complete ligation.

Twenty two animals with intrahepatic shunts and 56 with extrahepatic shunts underwent a second surgery. None of these animals died in the immediate postoperative period. There were eighteen intra- and postoperative complications reported. There was no significant difference in the complication rate between intrahepatic or extrahepatic shunts.

This study indicates that the acute mortality and morbidity does not differ between intra- and extrahepatic shunts. In addition, a second surgery is not associated with an increased mortality risk.
SUMMARY:

The authors philosophy regarding the treatment of intrahepatic shunt surgery, like extrahepatic shunt surgery remains driven by a few principles:

- No animal should be denied the benefit of complete permanent shunt occlusion on the basis of convenience alone.
- Full permanent occlusion of the shunt and recovery of liver function is the best outcome that can be achieved.
- More than one procedure may be required to achieve the above goals.

Multiple acquired shunts seem to develop in some animals regardless of the technique used but some may promote these more than others. Recanalization of previously thrombus-occluded shunts could potentially occur when ameroid constrictors, cellophane bands and intravascular coils are used. This complication cannot happen when the shunt is ligated with prolene!

FURTHER READING:


8: Lee KC, Lipscomb VJ, Lamb CR, Gregory SP, Guitian J, Brockman DJ. Association of portovenographic findings with outcome in dogs receiving surgical treatment


Imaging of Persistent Right Aortic Arch: Why and How?

Dr. Tobias Schwarz

Introduction

Persistence of the right aortic arch accounts for almost all aortic vascular ring anomalies in dogs and cats. The oesophagus is most commonly affected and its compression varies in site and severity according to the specific type of malformation. It is a congenital condition that can arise due to two different mechanisms that give rise to a right aortic arch either with or without mirror image branching. Only the anomalies with mirror branching form a ring around the oesophagus and trachea and are clinically relevant. Different types exist:

- Right aortic arch and left ligamentum arteriosum (most common).
- Persistent right ligamentum arteriosum with normal left aorta
- Double aortic arch (also tracheal compression)
- Persistent right aortic arch and aberrant left subclavian artery (incomplete ring)
- Persistent right aortic arch and aberrant left subclavian artery and left ligamentum arteriosum (complete ring, 2 strictures)
- Persistent right aortic arch and aberrant left subclavian artery and right ligamentum arteriosum (complete ring, 1 stricture)
- Aberrant right subclavian artery with left aortic arch
- Other vascular malformations may result in oesophageal entrapment

Survey Radiography

Diagnostic imaging is an essential part of the initial work up to rule out other diseases causing similar clinical signs, such as oesophageal motility disorders, strictures and foreign bodies. Survey radiography can also reveal secondary changes such as aspiration pneumonia, which are essential for case management.

Barium oesophagrams are controversial; due to the risk of aspiration barium studies should be avoided. In most cases, focal oesophageal distension can be diagnosed on survey radiographs. Only in a minority of cases does the contrast enhancement add to the visibility of the oesophageal distension.

The presence of a persistent right aortic arch anomaly in general can be diagnosed from survey radiographs. The trachea will be displaced ventrally and, more importantly, leftward and is usually focally narrowed. However the specific type of anomaly cannot be diagnosed.
Additional need for imaging:

95% of persistent right aortic arches consist of an aberrant right aortic arch and a left ligamentum arteriosum with no residual blood flow. A left-sided thoracotomy without further imaging would be sufficient. However there are several conditions that might warrant further imaging if available:

- Presence of a patent ductus arteriosus. Although this can be recognized at surgery, it is helpful to know this in advance for surgical planning.
- Aberrant left ligamentum arteriosum and subclavian artery warrant a left sided thoracotomy and surgery at one or two sites.
- Double aortic arch requiring a ventral approach.

These anomalies are not common, but with modern imaging techniques it is possible to diagnose these subtypes.

Selective angiography

Selective angiography can outline all major arterial vessels. However this is a relatively time-consuming procedure that requires great interpreter experience. The image interpretation can be very difficult.

Vascular CT

Multi slice helical CT allows imaging of a relatively large area within a very short time period. The use of a power injector is required for aortic arch imaging, but a peripheral venous injection is sufficient. Proper timing of the scan post injection is required and best achieved with a test bolus.

Requirements:

- General anesthesia
- Power injector (= injection pump), catheter in cephalic vein
- Respiration control

Technique:

- Timed contrast medium injection & scan start (test bolus, guess, bolus tracking)
- Inject low concentration i.v. contrast medium (240 mg Iodine/ml) @ 800 mg Iodine/kg
- Arterial phase images

Duration:

- 30 min

CTA allows identification of all patent vessels and the location of the oesophageal and tracheal constriction. The non-vascularized ligamentum
arteriosum remains difficult to see but its location can be assumed by the location of oesophageal compression.

**Conclusions:**
Survey radiography is essential in the work up of patients with suspected vascular ring anomalies. CT angiography is the modality of choice to investigate the specific type of anomaly.

**Further reading:**


Vascular Anomalies: 
Plugging the Gap – IR and (Cardio)Vascular Disease

Dr. Chick Weisse

INTRODUCTION

Interventional Radiology uses fluoroscopy to guide minimally-invasive therapies. There is currently expanding investigation into the use of these techniques in various areas of veterinary medicine, including but not limited to the arterial and venous systems. The morbidity associated with certain open surgical procedures in these areas, particularly in compromised patients, makes these minimally-invasive approaches increasingly appealing. Moreover, the lack of treatment alternatives available for more complex, terminal, or end-stage diseases when traditional therapies have failed has inspired research into potential uses for these techniques, many of which have become the standard-of-care in human medicine. This lecture will review some of the interventional procedures currently performed in the arterial and venous systems of veterinary patients and some of the lessons learned – or more importantly the new questions raised – using these techniques.

HEPATIC AVMS:

Vascular malformations have been classified as high-flow or low-flow, and as arterial, venous, lymphatic, or mixed. They are often associated with tumors but can also been seen congenitally in the liver (hepatic AVMs). Once called arteriovenous fistulas, they have been more recently termed arteriovenous malformations due to their vascular anatomy upon angiography. Interventional radiology techniques have allowed us to improve our understanding of these particular AVMs in terms of their vascular nature, response to treatments (glue embolization), and resulting pathophysiology. The observations below have been made following surgery or glue embolization of approximately 15 HAVMs.

*Lessons learned or questions raised concerning DIAGNOSTICS include:*

- These animals often present for clinical signs associated with PSS and are often mistaken for IHPS due to the ultrasonographic identification of a large intrahepatic vascular structure along with clinical signs consistent with PSS.

- While all of these animals have SEVERE PORTAL HYPERTENSION, about 25% of these cases will not present with ascites. This is presumably due to the multiple extrahepatic PSS that are acquired (along with other physiologic changes taking place) and have decompressed the portal system sufficiently to relieve the excessive hydrostatic pressure.

- Clinical signs are often less severe with HAVM than standard PSS presumably because the portal system is more developed in the former patients than in the latter ones.
- Other diagnostic signs that are less commonly discussed include hepatofugal portal blood flow (ALWAYS PRESENT), a reduction in aortic diameter caudal to the level of the celiac artery, and differing systemic blood pressures obtained from the forelimbs (higher) and the hindlimbs (lower) that is occasionally present. Identifiable abdominal bruit is rarely present in the author's experience.

Lessons learned or questions raised concerning TREATMENT include:
- It has been suggested in the human literature that while AVFs can be ligated or coil embolised, multiple AVFs or AVMs should receive glue embolisation (or alcohol ablation) in order to destroy the nidus that will otherwise recruit additional vessels over time. This has not been confirmed in the veterinary population but angiograms shown may support this notion.
- Initial angiography (and cross sectional imaging) often underestimates the extent of the disease. Following initial embolisation, additional previously unidentified contributing vessels open up demonstrating the true infiltrative nature of these vascular anomalies.
- Complete HAVM embolisation or resection appears to be required to prevent recurrence. Incomplete embolisation or resection will lead to revascularization if the HAVM nidus remains.
- These patients can tolerate complete hepatic artery embolisation and the cyanoacrylate glue appears to be permanent in the cases that have been followed to date, although the radio-opacity of the glue (Tantalum and Lipiodol) may diminish over time.
- Although return to hepatopetal portal bloodflow (towards the liver) would be considered the goal, this has not been seen in any of the cases treated to date. Acquired EHPSS are present in ALL patients and can be expected to remain in place providing the least resistance to portal bloodflow. Complete HAVM embolisation could conceivable result in stagnant portal bloodflow as the direction changes from hepatofugal to hepatopetal and near complete stasis has been identified but to date has not required intervention.
- Vascular contributions to the HAVM are not only from the hepatic artery but have also been identified to arise from the gastroduodenal artery, left gastric artery, and phrenic aa. Performing an aortogram following embolisation is recommended.

Lessons learned or questions raised concerning FOLLOW-UP include:
- As acquired EHPSS will never close, continued life-long medical therapy is often necessary (and indicated) in patients following treatment. Some animals may not need medical therapy however.
- It is unclear which animals may benefit from treatment. In certain cases with no overt clinical signs (for instance the cases without failure to thrive and massive ascites), these patients may not benefit from the treatment of the anomalies. Do all animals with HAVM require treatment? It has been suggested that chronic portal hypertension can lead to portal vein blunting and reduce portal perfusion. If so, is this an argument that all these animals should be treated as soon as possible?
PERIPHERAL AVFs:
Arteriovenous fistulae (a single communication between an artery and a vein) can occur following trauma, neoplasia, or congenitally. These can be treated safely with surgery, interventional embolisation, or a combination of both.

SLOW FLOW MALFORMATIONS:
Venous and lymphatic malformations are uncommon in veterinary medicine. The author has performed percutaneous alcohol ablation on a presumptive venous malformation but very little veterinary data exists concerning either the clinical progression of these or their response to therapy.

References available upon request
Beyond Ligating a PDA: Surgery that carries a Health Warning!

Prof. Dan Brockman

INTRODUCTION:

Although many trained surgeons are comfortable performing closed cardiac procedures such as ligation of a patent ductus arteriosus and sub-total pericardecotomy, only a few veterinary surgeons the world over perform open heart surgery regularly and perhaps even fewer can boast reliable long-term results for the therapy they perform. The reasons for this include: the prevalence of surgically correctable cardiac disease in veterinary patients, the apparent success of non-surgical treatment (eg. Balloon dilatation for pulmonic stenosis), the risk surgical treatment poses to the patient, the techniques currently available and the cost of such treatments. For these reasons, cardiac surgery in animals has fallen massively behind when compared to the repertoire of procedures currently offered to human patients with heart disease. Ironically, the techniques used in human patients to facilitate open heart surgery today are largely the same as the techniques developed by pioneers such as Gibbon, Lillehei, Taussig and others, as a result of experiments with dogs and cats. More recently, open heart surgery programmes have been or are being developed at different centres throughout the world, increasing the availability, safety and success of open heart surgical therapies in the dog.

TECHNIQUES

Traditionally, open heart surgery was performed under total venous inflow occlusion (TVIO), placing time constraints on the duration of procedures. The trade-off for increasing the “safe” occlusion time for a patient was a reduction in the likelihood of successfully reviving the patient at the end of the procedure.

Venous inflow occlusion

<table>
<thead>
<tr>
<th>Hypothermia Type</th>
<th>Time Constraint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normothermic</td>
<td>3 – 5 mins * (8 mins – Hunt)</td>
</tr>
<tr>
<td>Mild hypothermia (30 C)</td>
<td>9 mins</td>
</tr>
<tr>
<td>Moderate hypothermia (25 C)</td>
<td>15 mins</td>
</tr>
<tr>
<td>Deep hypothermia (20 C)</td>
<td>45 mins</td>
</tr>
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This time constraint often meant that procedures were designed to be fast rather than accurate and that some procedures needed to be aborted.
before the surgical goals were achieved. These techniques did, however, allow resection of fibromuscular atrial bands (as in cor triatriatum dexter), resection of pulmonic valve leaflets or placement of a pulmonary outflow patch to treat pulmonic stenosis, and the resection of right ventricular outflow tract tumours. Studies demonstrating the long-term results of, for example, pulmonary outflow patching under TVIO, do not exist. Although short-term survival for patients undergoing such procedures is high at some institutions, the evidence, via personal communication, is that long-term results are either poor or at least very inconsistent.

The ability to open the heart, without the time constraint that TVIO creates, would allow the surgeon to perform a more accurate operation for even the relatively simple congenital cardiac diseases such as pulmonic stenosis. This should result in better long-term results. Theoretically, such techniques would open the way not only for treatment of congenital heart diseases but also offer some hope for all the dogs that develop progressive acquired valvular disease. Longer duration open heart surgery can be achieved in two ways:

Cardiopulmonary bypass

| Controlled cross circulation / Heart-lung machine | Unlimited time |

The use of a large dog as the “oxygenator” as in controlled cross circulation is considered unethical in many countries, leaving the heart-lung machine as the best means to perform prolonged open heart surgery in dogs.

**Equipment:**

In addition to standard surgical and anaesthetic equipment, in order to perform open-heart surgery, an artificial pump (roller head pump) and an artificial lung (oxygenator) are required.
Personnel:

A dedicated co-ordinated team effort is required to perform operations under cardiopulmonary bypass. This team includes: two surgeons, two scrub-nurses, one anaesthetist, and an anaesthesia nurse or technician, a perfusionist to run the heart-lung machine and critical care specialists to perform the post-operative care for these animals. In addition, cardiologists need to be prepared to offer surgical therapy to their patients and need to co-ordinate the medical heart therapy prior to and following surgical therapy.

Re-inventing the wheel.

Unfortunately, over the last few years, those involved in such programmes have to a large extent had to re-learn the lessons learned by early workers in the human field of cardiac surgery many years ago. The author of this presentation has been involved in an open heart surgery programme for many years and has concluded, as other workers have, that:

1. All members of the team (cardiologists, surgeons, anaesthetist, perfusionist, critical care clinicians) have to be dedicated to the programme, understand their roles, and be co-ordinated by a single leader.
2. Size matters: the insult associated with being on a heart lung machine using current protocols is magnified in small dogs this means that small dogs often die of bypass related complications using protocols that are well tolerated by larger (>15kg) dogs.

3. At the start of a programme, attempt relatively simple operations in dogs that have not exhausted their myocardial reserve, preferably animals with congenital disease.

4. Dogs with end-stage heart disease are not good candidates for surgical therapy performed by an inexperienced team.

5. Because of problems associated with long-term patient anticoagulation, mechanical valve replacement is fraught with long-term problems, tissue valves, that don’t require patient anticoagulation, may be a better valve option for small animals.

6. This is an expensive, high risk endeavour that will be a drain on hospital resources, in order to survive within a hospital, it must be successful, that is the patients must at least survive.

The future:

As centres around the world gain experience and expertise in the field of open heart surgery, the repertoire of procedures will be extended to include congenital and acquired valve defects, along with other congenital heart disease. In addition, as skill levels increase, it will become possible for workers in this field to offer therapies to dogs of all sizes, along with cats and perhaps even horses.

OPEN RESECTION OF PULMONIC STENOSIS

Introduction

Congenital stenosis of the pulmonary outflow tract is, along with patent ductus arteriosus and subaortic stenosis, one of the three most common congenital cardiac conditions seen in the dog. It is rare in the cat. Pulmonic stenosis (PS) is characterized as being subvalvular, valvular or supravalvular, according to the anatomical location of the constriction. In the most common form of PS (valvular), valve pathology varies from fusion of otherwise normal valve leaflets within a normal valve annulus, to fibrotic deformed valve leaflets in a pathologically narrowed valve annulus. Secondary cardiac changes such as right ventricular hypertrophy can add a dynamic component to the stenosis that may influence treatment options and choice. In addition, concurrent anomalies of the coronary artery exist in some breeds, making treatment even more problematic.

Commonly, the severity of pulmonic stenosis is graded as mild, moderate or severe, based on the pressure gradient estimated, by calculation, from the velocity of blood flow across the stenosis, derived by Doppler
ultrasound interrogation. Such ultrasound examinations are typically performed in the conscious animal. Interestingly, historically, pressure gradients to classify the severity of a lesion were taken from pressure traces derived from catheter “pull-out” procedures that were performed in anaesthetized animals. However, the severity of the pressure gradient, the presence of clinical signs and the degree of secondary cardiac changes (right ventricular hypertrophy) are all taken into consideration when determining a treatment plan for an affected animal. Generally, animals affected clinically or that have “severe” disease on the basis of their pressure gradient, are considered as candidates for intervention.

Treatment options include procedures directed at the valve alone and procedures that have been designed to treat the valvular deformity, valve annulus narrowing and sub-valvular muscular hypertrophy simultaneously. No single treatment option is endorsed by a report of a carefully controlled clinical trial, with long-term outcome, in “significant” numbers of animals. Treatments that carry the least risk to the patient like balloon valvuloplasty (BV) have, therefore, gained popularity despite the lack of evidence documenting long-term efficacy in small animals, largely because of the well-documented effect of similar techniques in human patients. The “higher risk” surgical procedures have been reserved for dogs that have failed non-surgical treatments or dogs that are not considered “good” candidates for non-surgical treatment.

**TREATMENT OPTIONS**

**Valve alone:**

1. **Balloon valvuloplasty:** Often the first-choice for clinicians treating valvular PS in a breed that doesn’t suffer from aberrant coronary artery anatomy, (even if subvalvular infundibular muscular hypertrophy exists) where the pulmonic valve annulus is a normal size.

2. **Closed valvulotomy:** Using a mechanical valve dilator. Largely superseded by BV.

3. **Open valvectomy via pulmonary arteriotomy:** Performed under total venous inflow occlusion (TVIO). Used in dogs/cats when valvular disease alone is present and in patients that have failed BV or in patients where BV was not possible or considered inappropriate.

**Valve, valve annulus and muscular hypertrophy:**

1. **Closed patch grafting.** Six dogs reported in the literature.

2. **Modified open patch grafting**
   
   - *Orton – partial ventriculostomy under TVIO* Four dogs reported.
• **Hunt** – “quick sew” under TVIO. Eight dogs reported in the literature.

• **Sackman** – incised patch under TVIO. Book chapter.

3. **Open patch grafting (Cardiopulmonary bypass)** None reported in literature. Success described by several workers. Perhaps gives the best opportunity to examine the valve leaflets and excise hypertrophied muscle. Most accurate placement of a “patch”. Not appropriate for small patients!!

4. **Conduits.** Only failed conduits reported in clinical cases in the literature. Success has been described by some workers.

For many patients with severe or symptomatic PS balloon valvuloplasty represents the safest first line of treatment even if infundibular muscular hypertrophy exists. For patients with predominantly valvular disease (i.e. normal valve annulus), in which BV is not possible or fails, the best view of the RVOT is achieved under CPB. Although this approach is associated with the highest short-term risk to the patient it probably offers the best chance at long-term palliation or improvement.

**ATRIOVENTRICULAR VALVE REPLACEMENT**

**Pathoanatomy:**

The mitral and tricuspid valve can suffer from both congenital and acquired (endocardiosis) deformity that creates predominantly valvular incompetence and occasionally stenosis. Replacement of such valves in people, is commonly performed and typically is done before secondary myocardial changes are advanced.

**Valve replacement in dogs:**

Experience with replacement valves in dogs is in its infancy. Mechanical valves have been placed in the mitral position in dogs but although dramatic results were obtained in the short-term, difficulty in maintaining life-long anticoagulation resulted in devastating failure of the valve in many patients. Tissue valves (valves made from bovine pericardium or porcine valves) obviate the need for life-long anticoagulation in people and should be similar in the dog. Early results of tricuspid valve replacement using both bovine pericardial and porcine aortic valves, suggest that inability to manage anticoagulation even in the short-term can prove devastating in the long term for dogs undergoing valve replacement.
SURGICAL MANAGEMENT OF TETRALOGY OF FALLOT

Pathoanatomy
The primary pathoanatomy seen in dogs with Tetralogy of Fallot (ventricular septal defect, pulmonic stenosis and overriding aorta) can all be explained by embryological developmental defects of the endocardial cushions comprising the conotruncal septum.

Pathophysiology
Right to left shunting of blood results in underperfusion of the lungs resulting in systemic hypoxia and cyanosis. Compensatory polycythemia may be seen. The contribution of infundibular muscle to the right ventricular outflow tract obstruction can create both a dynamic and progressive component to this disease, accounting for worsening of signs with exercise and progression of disease despite fixed valvular and septal abnormalities.

Therapeutic options

Medical/conservative: Some mildly affected animals not require any treatment and will enjoy a good lifestyle, others will require medical therapy (beta-blockers) to give an acceptable quality of life. It has been suggested that approximately 25% of affected animals will not be controlled by conservative/medical means (Eyster and others 1976).

Surgical: Surgical treatments fall into two main categories: primary repair and palliative procedures.

Primary repair of tetralogy of Fallot has been described several times in the veterinary literature (Heritage and others 1983, Lew and others 1989) this requires cardiopulmonary bypass, advanced surgical expertise and currently carries a high mortality rate.

Palliative surgical procedures: These were used extensively in human medicine prior to the advent of cardiopulmonary bypass and primary repair. Currently, some are used in infants as a “bridge” to primary repair, in severely affected individuals.

1. Potts anastomosis. (Side to side anastomosis of the aorta to the left main pulmonary artery)
2. Blalock anastomosis. (Anastomosis of the left subclavian artery to the left main pulmonary artery)
3. Modified Blalock-Taussig anastomosis. The development of synthetic materials such as polytetrafluorethylene (PTFE) (Gore-Tex) that are relatively non-thrombogenic and can be created in tube form has allowed surgeons to modify existing techniques.
4. Others: Microvasular anastomosis of the left internal thoracic artery to the pulmonary artery has been described in a cat that had a failed “Fontan” procedure (anastomosis of the right atrium to the pulmonary artery)
References


