Emergency TECHniques: Placement And Maintenance Of Peripheral Intravenous Catheters
Andrea M. Steele, MSc, RVT, VTS(ECC)
Ontario Veterinary College, University of Guelph, Guelph, Ontario, Canada

Vascular Access in Veterinary Patients
Intravenous catheters are the most common invasive device placed in veterinary patients. Every veterinary nurse should be skilled in the performance of this task. IV catheters allow us to have emergency venous access for anesthetized patients, access for IV medications, fluid therapy and aid in euthanasia.

Catheters can be placed in various locations in veterinary patients:
Type 1:

- **Peripheral**: the two most common are the:
  - Cephalic Vein
  - Lateral or Medial Saphenous Vein
- The **advantages** of the Cephalic and Saphenous include:
  - Large size: they are reasonably large veins that can be catheterized with a large bore (usually up to 14 or 16 gauge catheters in a large dog) easily.
  - They are the ones you know...most typically catheterized, so even when flat, they can be hit by a skilled person, based on suspected location
- The **disadvantages** to using these veins include:
  - Saphenous or other hind limb catheters are contraindicated in an uncompressed GDV (remember the pooling of blood in the hind limbs due to extracardiac obstruction)
  - Because they are peripheral they are most responsive to vasoconstriction and in a very shocky patient may be very hard to find, hit and feed.
- **Other peripheral sites which are sometimes successful include**:
  - Metacarpal and metatarsal veins: just like on the back of your hand, the veins on the plantar aspect of a dog's foot are often easy to hit (they are very shallow) with a small gauge catheter
  - Femoral vein (has same disadvantage as saphenous in GDVs)
  - In general, the peripheral veins may be too difficult to hit percutaneously, and may require a cut-down when a patient is severely shocky.

Type II: **Central Veins**:

- Most commonly we use the Jugular Vein
• We can also introduce a Long Saphenous catheter into the caudal Vena Cava
• The jugular vein is most appropriate during an emergency, although a long saphenous is great for continued care.

Keep in mind, when an animal is in the compensatory or early decompensatory stage of shock, the body's primary goal is to maintain blood flow to the brain and heart. The jugular vein is a big part of that pathway. While studies have shown the placement of a central catheter does not improve outcome over a peripheral catheter (as often thought), sometimes, a jugular catheter is easier to place because there is actually blood in it!

In my experience, if I have a very shocky patient, I try a peripheral first, but if I cannot get it, and based on experience believe that repeated attempts would not help, I move to the jugular vein. Usually, if the animal is not in terminal shock, the jugular is still distended enough to feel, and I can usually feed a 14 or 16 Gauge over the needle type of catheter into it percutaneously.

Often if the patient is already in terminal shock, the only choice is to perform a cut-down on the jugular vein (or a peripheral vein) or place an IO catheter, as a last ditch attempt to gain access.

Type III: Intraosseous (IO) Catheters:

While not technically an intravenous catheter, IO catheters do allow access to the intravascular space, and are very useful in an emergency.

Sites include:

• Trochanteric fossa of the proximal femur
• Greater tubercle (head) of the humerus
• Tibial tuberosity
• Wing of the ilium

IO catheters are often used in neonates, pocket pets and birds. These can also be used in larger animals, however they can be more difficult and time consuming to place for inexperienced persons. In young puppies and kittens that a 20 G 1” or 2” catheter can be readily placed into the jugular vein, and we rarely have to resort to IO catheter use.

Rapid IO Catheters and Drill:
More recently, a new system for rapid introduction of IO catheters in veterinary patients has been developed. It is called the “EZ-IO Intraosseous Catheter Kit®” by Vidacare and is distributed by MILA. It has been used for years in human emergency situations. The kit is comprised of a drill, and short, large gauge needle sets (stylet and needle), with a matching connector to the drill. The needle is attached to the drill, and rapidly introduced into the tibia or humerus (most commonly). The stylet is removed, a fluid set is attached, and within seconds, resuscitation has been initiated.

We have had tremendous success using this system, on those flat shocky dogs that there is a delay in getting a peripheral catheter. We have also used this system on mini-pigs that have come in, as they are notoriously difficult to catheterize. Generally, we pull the IO catheter once venous access is obtained.

**Types of Intravenous Catheters**

**Butterfly Catheter**

- Suitable for single injections of drugs or fluids, or blood collections
- Should not be taped into the vessel
- Remove as soon as finished
- Work well in performing thoracocentesis or abdominocentesis

These catheters do not really have a role in emergency vascular access, but they are very useful for blood collections and single injections.

**Thru the Needle catheter**

- Inexpensive catheter for central lines
- Often do not last very long
- Difficult to stabilize, especially in large jowly dogs
- Fairly simple to place

Not suitable for emergency use due to small bore, and long length, but work very well as a short term central line.

**Over the needle catheter**

- Most common type
• Suitable for a variety of patients
• Can be left in place
• Polyurethane has been tested to cause less irritation to vein

Usually easily placed in emergency situation.

**Long term catheters**

• Expensive (~$50-100)
• Require expertise to place
• Generally placed once patient is *stable*
• If properly placed and maintained, can last a month or longer
• Multiple lumens allow for infusion of multiple drugs, PPN, fluids etc.

Great for blood sampling! Make for a much happier patient as they help to avoid multiple venipunctures.

**PLACEMENT OF PERIPHERAL IV CATHETERS**

As the most common type of IV catheters placed in veterinary medicine, we will take a significant portion of our lecture to discuss tips and tricks to their placement. These tips will be augmented with photos and video, so we will only discuss them briefly in this manuscript.

In short, here are some things to keep in mind:

1. The cephalic and saphenous veins are desirable as they are both very shallow veins that can readily be seen. (if you can “see” it, you have a much better chance of hitting it)
2. The saphenous vein requires some stabilization, usually with a thumb on the skin. This does require caution to avoid contaminating the catheter site and catheter.
3. A clean gauze placed at the bottom of the prep site can be used to position the vessel and hold it firmly, in addition to keeping the catheter from tracking through hair.
4. Remember that entry to the skin should be a 30° angle, then once through, you can flatten out a bit to enter the vein. 30° allows you to use the sharpest point of the catheter, and makes it more comfortable for the patient
5. Remember that the catheter is not right at the end of the stylet! Thus, in order for the catheter to easily enter the vein, the entire catheter must be advanced and well seated prior to pushing off the stylet.
6. Hold the stylet steady, and push off the catheter… do not withdraw the stylet until the entire catheter is in place.
7. Taping is the most important part of placement:
a. Ensure that the catheter is taped securely to avoid movement… movement causes trauma to the site, and encourages bacterial growth

b. Keep the catheter on the same angle as the vein. Avoid bending the catheter in any way, and this will help to minimize kinks.

8. Bandaging is an “art form”, and needs to be snug, but not too snug, and also consider tissue swelling in a patient receiving IV fluids.

MAINTENANCE OF IV CATHETERS:

It is important to have clear policies in your hospital regarding maintenance of IV catheters. Timed remove and replace policies have largely been “debunked” in both human and veterinary medicine. Instead, a remove and replace as needed policy should be instituted, accounting for the individual nature of our patients. Some patients will react to the tape used, causing discomfort, phlebitis, extravasation, etc., will all cause significant problems. Catheters should be removed if causing pain (a dog is reacting to flushing, or is limping on the IV limb suddenly), or if there is redness or swelling above the catheter.

Using catheters that have a softer texture to them, such as polyurethane catheters, rather than Teflon catheters, usually is less reactive in our patients and allows the catheter to remain in longer. They are a few cents more expensive, but worth it in the long run for patient comfort.

Bandages should be examined daily for wetness or damage, and replaced if necessary. The site should be visualized daily, and the limb palpated for any pain. Bandages should be removed and replaced immediately if it is noted that the toes are swelling.

In general, a well placed catheter should last for several days. Learning to place catheters using best practices is important for every veterinary nurse and we will discuss these best practices further in the lecture.
FIRST IMPRESSIONS: TRIAGE OF EMERGENCY PATIENT
Andrea M. Steele, MSc, RVT, VTS(ECC)
Ontario Veterinary College, Guelph, Ontario, Canada

Learning Objectives:
1. Learn to categorize emergency patients in order of priority
2. Understand rapid methods of assessing emergency patients
3. Recognize difficult to assess patients and owners

Every Veterinary Practice should have a plan for emergencies. Technicians who perform triage in either situation should have a clear understanding of what the veterinarian in charge wants them to do once they have triaged the patient. Should the patient be brought right to the treatment area and the veterinarian notified as this is happening? Should the veterinarian be notified while the patient is at the front and allowed to make the final call on treatment themselves? Is the technician allowed to initiate emergency action in the veterinarian's absence (such as oxygen supplementation, CPR, placing a compression bandage)? All of these actions should be discussed in advance amongst the veterinary team.

When an emergent patient arrives, assessing and triage are most often performed by a technician. Triage, is a process for sorting the ill or injured into groups based on their need for or likely benefit from immediate medical treatment. It is a method of "prioritizing" patients, and is used when a number of emergencies are waiting at once. It is one of the most important aspects of emergency medicine.

Presumably, most of the attendees of this lecture work in a situation where triage plays an important role. Emergency practices, specialty practices and general practices all benefit from excellent triage skills.

When we see an emergent patient, we all have our “gut feelings” and can in most cases easily place them into triage classes with minimal effort.

To categorize patients, we use a triage scale:

**Class I:** catastrophic, must be treated within seconds
**Class II:** critical, must be treated within minutes
**Class III:** urgent, must be treated within one hour
**Class IV:** less urgent, should be treated within 24 hours

And, to provide some examples of each Class:

**Class I:**
These are the patients where you take one look and whisk them to the back for emergency intervention:
Cardiopulmonary arrest
Respiratory arrest
Status epilepticus
Penetrating thoracic wounds
Severe GDV
Severe trauma
These patients are about to die or dying and need to be seen within SECONDS!

**Class II:**
These patients are just slightly less critical than Class I’s:
Severe dyspnea
Shock
Toxicity
Penetrating abdominal wounds
Hemorrhage
Head trauma
Pericardial effusion
Moderate to severe pain
These patients need to be seen within MINUTES! They present alive, but are teetering on a fine line where any stress can push them over.

Class III:
Trauma without shock or altered mentation
Open fractures
Urethral obstruction
Pleural effusion (compensating)
Mild to moderate pain
These patients need to be seen/treated within one hour

Class IV:
Should be seen within 24 hours:
Lameness
Mild vomiting/diarrhea without dehydration
Inappetance
--etc

In many cases, a Triage Class can be difficult to assign to a patient. There may be many reasons for this, and this is where the “ART” of Triage comes into play. While ultimately, triage can rely on “gut instincts”, in reality, we are using several methods of observation to come to a conclusion about the patient. The initial task is to perform a Primary Survey, which will give brief information on the most important aspects of the patient’s condition. There is an “ART” to how the survey is performed….the order or manner in which we perform the survey may change based on how we perceive the patient’s status.

The Primary Survey is based on the ABC’s, where:

A: Airway/Attitude
B: Breathing, Bleeding
C: Cardiovascular, Circulation

The Primary Survey can be further broken down into three actions: LOOK, LISTEN and FEEL. All of the ABC’s can be assessed using these actions. The primary survey begins as you LOOK at the patient from a distance, then approach, and finally touch the patient. Keep in mind that if a patient “fails” any of the actions along the way, the Primary Survey must be aborted and emergency treatment initiated.

From a distance, without moving, LOOK at the patient:

Airway: Is the patient breathing? NO? obviously the primary survey is aborted and emergency treatment is initiated. If breathing, LISTEN (still from a distance) to the breathing: can you hear respiratory sounds associated with inspiration or expiration?

Assess the quality of the respirations: what is the respiratory pattern like? Is it regular or irregular? Shallow or very deep? Is there increased effort (abdominal component)? Is the rate normal or abnormal?

Attitude: Is the patient bright, alert and responsive, quiet, alert and responsive, or are they non-responsive? Are they interacting with their owner?

Breathing: what is the respiratory rate? RR is always best assessed before approaching the patient and observing at rest while they are relaxed with the owner. This same concept is important when observing a hospitalized patient: always assess the RR before opening the cage door.
**Bleeding:** Is there visible bleeding? Is the bleeding arterial (pulsating, copious)? Is it compressible? (again, a very good point to stop the primary survey if bleeding is present)

**From a distance,** very important information has been obtained, and our gut instincts may be working overtime. At this point the Triage Class of this patient may be obvious, or further information may be required. If further information is necessary, we must approach the patient. Approaching the patient should evoke some response in a healthy animal. For example, a healthy dog may wag its tail, sniff the air, stand up to greet you, or it may move into a protective position in front of its owner (even many very ill dogs may still do this). Cats in carriers can be difficult to observe, so try to ask the owner to move the cage into a more visible position. Observe the cat’s ear positions, pupil size, and its general demeanor. It may exhibit fear, interest, disinterest, or may be non-responsive. Again, these cues or responses are used in assessment of the triage scale.

After approaching the patient, **LOOK, LISTEN** and **FEEL** can be used to finish the Primary Survey:

**LOOK:** Note the response of the patient to your presence and touch. Look at the mucous membranes and note the colour (normal pink, cyanotic, injected pink, muddy, brown) and while you are assessing, check the capillary refill time (2 seconds or less is generally considered normal).

**LISTEN:** Quickly auscult the heart, lungs and trachea. Does the heart sound regular? Is there a murmur? Are there increased lung sounds? Auscult the trachea to assist in localizing where the sounds are coming from (large airways vs small airways and parenchyma).

**FEEL:** assess pulses: strong, weak, bounding, pulse deficits? Do the mucous membranes and limbs feel warm, cool or hot to the touch?

**Remember, at ANY point during the primary survey, we can discontinue and initiate emergency treatment as necessary.**

It is important to note that there is no need in the primary survey for numbers. For example, heart rate, there is no need to know it is 22 or 289 bpm in a large dog. **ABNORMAL** (bradycardic, or tachycardic) or **NORMAL** is sufficient information. Counting for 15 seconds and multiplying a HR/min is a waste of time in this initial phase.

Having completed the **Primary Survey,** what information has been determined?

**Airway:**
- The animal is in fact breathing, or NOT
- Audible respiratory sounds (which may indicate upper airway obstructions) if present

**Attitude:**
- The animal is responsive or unresponsive
- The animal does or doesn’t react normally to its surroundings

**Breathing:**
- An approximate respiratory rate has been noted as NORMAL or ABNORMAL (fast or slow)
- Respiratory pattern: normal, increased effort, shallow, irregular has been noted
- The chest has been briefly auscultated assessing for abnormal respiratory noises
- Mucous membranes have been assessed for signs of cyanosis or other derangements

**Bleeding:**
- The presence and degree of obvious hemorrhage has been noted, and whether it is compressible (for example on a limb)

**Cardiovascular:**
- Heart rate has been assessed and determined if ABNORMAL or NORMAL
- Heart rhythm has been assessed for arrhythmias
- Heart sounds have been assessed for murmurs, dullness, or other abnormalities

**Circulation:**
- Mucous membrane colour and capillary refill time has been assessed
• Pulse strength, regularity
• Limbs and mucous membranes have been assessed for temperature (indication of vasoconstriction or vasodilation)

All of this information will come together to determine the patient’s Triage Class. The entire process should take one or two minutes MAXIMUM. Remember however that not all of this information is needed to make the determination for a Class I or sometimes II patient…stop the primary survey as soon as the class is obvious.

In other cases, it may be difficult to determine the Class based on several factors:

1) Patients may act differently in the clinic than at home, and just because they perk up does not mean they are not seriously ill. What you are observing may not be how the owner has seen the patient. Respect what the owner says and include that in your judgment…in many cases, the owner is right!

2) Avoid “Red Herrings”! An example: An owner walks in with her 8 year old Labrador Retriever and says he had a “fit” (often a common layperson’s name for a seizure), and it has never happened before. The receptionist, being well trained, asks her to have a seat and calls you to the front to assess the dog. Automatically, you would put a single, isolated, first-time seizure in a class III or IV position. However, you must keep in mind that the owner may not be able to distinguish a seizure from collapse or syncope. So, being very thorough, you perform your primary survey: The lab is lying comfortably at the owner’s feet. He is mildly tachypneic, with no increased effort or audible sounds. He otherwise seems comfortable. You move closer to him, and he lifts his head and gives a small tail wag, then puts his head back down. You move in to complete your primary survey…so far you have noted a quiet dog, but are not too concerned. You auscult his heart and find him to be quite difficult to hear, tachycardic and somewhat irregular. You lift his lip, and find his mucous membranes are very pale, and to finish it off, a quick feel of his pulses and SURPRISE! they are quite weak.

All of this took less than a minute to determine that this patient should be moved to a Class II and seen within minutes. This probably wasn’t a seizure…this was more likely an episode of collapse secondary to pericardial effusion or a hemoabdomen. Treatment should be instituted within minutes!

3) In many cases, the owners will feel that the condition is a true emergency. For example, many owners will see a tapeworm segment and feel it is an emergency. It is important to explain to owners the triage system and that patients are seen in a priority, rather than order of arrival system. Having a nice sign in your waiting room explaining triage is always a good idea. Remind owners that the same system applies at human hospitals…the most critical patients are seen first. Always offer and provide emergency service to people that wish to wait, but keep them updated on how long a wait it will be. It is perfectly normal for owners to be extremely anxious about their pets, and their idea of a true emergency may be different from ours. Use the “primary survey” as your guideline.

4) If in doubt, don’t make assumptions: reassess the patient in 5-15 minutes, or treat immediately. Some patients just do not fit into the Classification system well. Trust your gut, even when the numbers are normal. There may be a cue that you are reacting to that may be subtle, but you just can’t put your finger on it. Trust your experience!
Not only is it important for technicians to know when they should use various monitoring instruments, it is even more important to understand how each device works and their limitations. This lecture reviews the function and use of various monitors including pulse oximeter, oscillometric and Doppler blood pressure, and an ECG interpretation of common arrhythmias.

**Pulse Oximetry**

The pulse oximeter is a valuable tool that will provide a measure of the % saturation of hemoglobin with oxygen. This is an important number to be aware of, especially when dealing with the emergent or maintenance phase of a respiratory patient. Many clinics do not yet possess the ability to perform blood gas analysis, and the pulse oximeter will provide some information on the respiratory compromise of the patient.

The pulse oximeter works on the principle that hemoglobin changes color depending on which state it is in. The two normal states are oxyhemoglobin (red) and deoxyhemoglobin (blue-purple). Essentially, the more oxygenated the hemoglobin is, the more “red” it appears. Knowing this, two sensors are on the pulse oximeter probe, a red light and a infrared light. Oxyhemoglobin absorbs infrared light, allowing more red light to pass through. Deoxyhemoglobin absorbs red light, allowing more infrared light to pass through. Photodetectors measure the amount of each light passing between the area being measured, and determine the percentage that is red vs infrared, and gives a reading, the SpO2, or percent saturation of hemoglobin with oxygen. Pulse oximetry requires pulsatile blood flow and therefore needs to be over arteriole beds to work effectively.

The pulse oximeter relies on the Oxyhemoglobin dissociation curve. It is very important for us as technicians to have a thorough understanding of this curve. The Oxyhemoglobin dissociation curve describes the relationship between the PaO2 (or partial pressure of oxygen dissolved in the blood) to the SpO2.

The curve shape is very important, it is sigmoid (s-shaped), which is indicative of an initial rapid growth to a certain point, and then it begins to slow causing the curve to flatten out. It is not a simple linear relationship. The point at which the Oxyhemoglobin dissociation curve begins to
flatten is at a PaO\textsubscript{2} of 70 mmHg. Hypoxemia (insufficient oxygen in the blood) occurs at a PaO\textsubscript{2} of 70 mmHg (and continues to become more severe as the PaO\textsubscript{2} decreases). While the visual of the oxyhemoglobin dissociation curve provided during the lecture will help to solidify this information, extrapolating from 70 mmHg (the minimum desired PaO\textsubscript{2}) will give approximately 92\% on the SpO\textsubscript{2} (vertical axis). This means that in general, a reading of 92\% on the pulse oximeter, is likely consistent with hypoxia.

The pulse oximeter reading can be affected by a number of factors which will be discussed during the lecture.

**Arterial Blood Pressure (ABP)**

ABP is measured in two phases, systolic and diastolic. Systolic arterial pressure (SAP) is the phase during which the ventricles are contracting, and the left ventricle pushes blood into the systemic circulation. It is the maximum arterial pressure. The diastolic arterial pressure (DAP) is the minimum arterial pressure. DAP occurs during diastole, when the ventricles are relaxed and filling with blood. The mean arterial pressure (MAP) is the average arterial pressure during one cardiac cycle and is determined by the following equation:

\[
MAP = DAP + \frac{(SAP - DAP)}{3}
\]

Diastole is approximately two-thirds of one cardiac cycle, therefore the MAP is closer to the DAP then it is to the SAP.

Upon contraction of the ventricles, blood is pushed into the aorta, a large, compliant vessel. Blood moves from the aorta into increasingly smaller, more resistant arteries, and as it does so, the SAP increases, while the DAP decreases. Overall, the MAP is maintained consistent as the pressure wave advances. This can be explained by the following equation:

\[
MAP = CO \times SVR
\]

Where:  
CO = cardiac output  
SVR = systemic vascular resistance

The equation shows that an increase or decrease in either CO or SVR will have a dramatic effect on MAP. When assessing ABP in veterinary patients, it is important to realize which of the factors (CO or SVR) is having the most impact on ABP, as it may influence which drug will be used to treat hypotension.
The normal ABP for dogs and cats is 120/80 mmHg (SAP/DAP) with a MAP of 80-95 mmHg. In general, maintaining MAP > 60 mmHg will ensure adequate perfusion to the brain, kidneys and myocardium.

The cardiac cycle generates a palpable pulse wave. The pulse pressure is defined as:

\[
\text{Pulse Pressure} = \text{SAP} - \text{DAP}
\]

Therefore, the larger the difference between the SAP and DAP, the stronger the pulse. Palpation of proximal and distal pulses is considered a subjective method of approximating ABP. The most commonly used are the femoral, dorsal pedal and lingual pulses. Pulse quality can readily be assessed using the femoral artery. Distal pulses such as the dorsal pedal can provide more information, as absence of a pulse indicates the MAP has fallen below 60 mmHg. The subjective method should always be used when monitoring a patient, especially under anesthesia. This method works best however in tandem with an instrumented method to provide the most information.

ABP can be measured using two methods: Non-invasive blood pressure (NIBP, or indirect) and invasive blood pressure (IBP, or direct).

**Non-Invasive Blood Pressure**

NIBP is the most common and least expensive method for determining ABP. The two NIBP methods are the doppler flowmeter and oscillometric unit.

**Doppler Flowmeter**: Today, most veterinary practices are capable of obtaining SAP. This is performed using a device called a doppler flowmeter. This device detects blood flow by emitting an ultrasonic signal, while simultaneously receiving a returning signal. The signal is converted to a sound (the “swoosh”) which is the difference between the frequencies of the emitted and returning signals. The SAP is determined through the use of an occlusive cuff and sphygmomanometer and is the point at which the sound disappears, indicating that the pressure in the cuff is identical to the pressure required to occlude the artery. In some cases, the doppler can be used to distinguish the DAP, as a second sound can often be distinguished as the cuff is allowed to deflate. This requires more expertise, and is more variable from person to person and patient to patient, so many operators only read the SAP with the doppler. The doppler is best used on small patients such as cats and small dogs, but works on any size providing an
appropriately sized cuff is available. Doppler flowmeters are considered the most accurate indirect method of blood pressure measurement.

**Oscillometric**: Oscillometric blood pressure units are also readily available for veterinary use, and have been well established in the literature as an accurate method to obtain SAP, MAP and DAP. They also provide a pulse rate which is essential to help determine the accuracy of the reading. While they are rarely effective in cats and very small dogs, they are generally the best method for medium to giant dogs.

Oscillometric machines are automated and inflate an occlusive cuff until approximately 40-50 mmHg beyond the point of occlusion. The pressure is then gradually released until the machine detects the maximal oscillations (MAP). Pressure release continues until full blood flow is detected and the machine uses a proprietary algorithm to calculate the SAP and DAP.

In dogs with low ABP or arrhythmias, the oscillometric method may be inaccurate or fail to give a reading. If there is difficulty with an oscillometric machine, using a doppler to confirm the ABP is preferred.

In general, with both doppler and oscillometric units, choosing the appropriate cuff size for the patient is very important. A cuff that is too small will falsely elevate the ABP reading, while one that is too large will falsely lower ABP reading. The ideal cuff size is determined by its width, not its length. By laying the long axis of the cuff along the long axis of the limb, the width (short axis) of the cuff should be able to wrap around approximately 40% of the limb in dogs, or 30-40% of the limb in cats. This can be most accurately assessed using a measuring tape to measure the circumference of the limb where the cuff will be placed. Some machines require that an artery be placed directly under a specific area on the cuff.

Cuff placement is very important for both methods, and placement should remain consistent with every reading. In cats or dogs the limbs or tail can be used. With either method, the cuff should be placed as close to the level of the right atrium as possible. In an awake patient, restraint is often required to place the patient in lateral recumbency which can be stressful, causing an increase in ABP. The tail is considered by many to be the least stressful and most reproducible site for an awake cat for a doppler measurement. The tail (when present) is also an excellent site to use on an awake dog when unwilling to lie down. In the anesthetized
animal, probe and/or cuff placement is often determined by the surgical site. Doppler probes can be taped in place on the limb or tail, and an IV extension set can be used to attach the cuff to the sphygmomanometer allowing the anesthetist to work more remotely. Oscillometric units have a long line which allows the cuff to be placed on a limb under the surgical drapes and the machine set to one side.

With either occlusive method, the operator must allow sufficient time between measurements for limb perfusion. Continuous measurements have been identified as a potential cause of limb ischemia and venous pooling, especially in hypotensive patients. Repeated measurements should be limited to every three minutes, or for only short time periods on rapid cycling.

**Electrocardiography**

**The Sinus Beat**

The normal sinus ECG complex involves 3 distinct wave forms: P-wave, QRS complex (which is actually three waves in close relation to one another), and the T-wave.

The P-wave reflects atrial depolarization. The QRS complex is the ventricular depolarization. The T-wave is the ventricular repolarization. This is important to understand, as p-wave abnormalities indicate atrial dysfunction, while QRS abnormalities signify ventricular dysfunction.

The heart is a muscle, and muscles are driven by electrical stimuli. In the case of the heart, we have a conduction system that includes:

The Sino-Atrial (SA) Node:

- Coordinates all electrical activity in the heart
- The cells of the SA node do not require direct stimulation of the nervous system to initiate an action potential
- *aka* the primary pacemaker

The Atrio-Ventricular (AV) Node:

- Transmits electrical stimuli from the atria to the ventricles
- Allows coordination between atrial and ventricular contraction
- Moderates the contraction of the ventricles when there is excessive atrial stimulation

The Bundle of HIS:

- A short electrical route connecting the AV node and the Bundle Branches.

The Bundle Branches:
• Transfers electrical current from the Bundle of His to the left and right ventricles

The Purkinje Fibres:
• The terminal fibres of the bundle branches in the myocardium

Abnormalities in the conduction system of the heart lead to cardiac arrhythmias, which are represented on the ECG.

**Arrhythmias**
Cardiac arrhythmias can be atrial or ventricular in origin, and are common cardiac emergencies. Arrhythmias may occur in bursts, episodes, or be sustained for long periods of time. Depending on the type of arrhythmia, treatment will vary and the rapidity and criteria for treatment will vary. Common arrhythmias are divided into two categories: *Bradyarrhythmias* (arrhythmias with a slow rate) and *tachyarrhythmias* (arrhythmias with a fast rate)

**Bradyarrhythmias**

**First Degree Atrioventricular Block**
1\(^{st}\) Degree AV Block is caused by prolonged conduction through the A-V node, resulting in a prolonged P-R interval. This may be normal for the patient, and is rarely treated unless the patient is extremely bradycardic. The patient is responsive to atropine and glycopyrrolate. This arrhythmia can be associated with drug therapy, and is also seen in hyperkalemic patients.

**Second Degree Atrioventricular Block**
2\(^{nd}\) Degree AV Block comes in two forms; 1) Mobitz Type I, and 2) Mobitz Type II. Of the two, Mobitz type II is the more serious condition. Mobitz Type I is often a transient condition often seen when a patient has increased vagal tone (abdominal pain, vomiting) and is often seen after an insufficient dose of glycopyrrolate. Characteristics include: lone p-waves without an accompanying QRS complex, and a slightly longer P-R interval following the blocked beat. Type I is responsive to glycopyrrolate or atropine, and will resolve immediately. It is also known as Wenckebach.

Mobitz Type II is a potentially more serious condition where again, there are lone P-waves without an accompanying QRS complex (which may occur in multiples) and a consistent P-R interval. It can lead to severely reduced cardiac output if the ventricular rate is very low, and is NOT responsive to atropine or glycopyrrolate. This condition may require a pacemaker placement.

**3\(^{rd}\) Degree Atrioventricular Block**
3rd Degree AV Block has a somewhat similar appearance to 2nd Degree, Type II, often with multiple P-waves before a QRS. The difference is that the P-waves have no association with the QRS complex...in other words, the QRS’s appear at random. The QRS’s that do appear are called escape beats, and are initiated from foci within the ventricles. This rhythm is usually not responsive to atropine, and most often requires placement of a pacemaker.

**Tachyarrhythmias**

**Atrial Fibrillation**
Atrial fibrillation results when many foci fire repeatedly within the atria. This gives the characteristic undulating baseline. The activity of the atria causes increased ventricular firing, resulting in a rapid ventricular rate with an irregular rhythm. This is the arrhythmia which has been likened to the “tennis shoe in the dryer” when auscultating. Often at very fast rates, it is difficult to discern from SVT, as the rhythm may appear regular...if the rate slows slightly it becomes easier to see that it is indeed irregular. A-fib is typically seen in disorders causing atrial dilation, such as cardiomyopathy.

**Supraventricular Tachycardia**
As the name implies, this arrhythmia occurs “above the ventricles”...meaning in the atria. SVT is caused by ectopic foci within the atria. The complexes can be very tall and narrow, and often it is difficult to discern P and T waves...there is often a single wave between QRS’s that encompasses both the P and T-wave. SVT can be an extremely rapid rate, often in the high 200’s to 300’s. It is caused by bursts of premature atrial contractions (APC’s) that can be transient or sustained. When sustained, cardiac output is severely compromised, and patients can deteriorate quickly. SVT may be broken by increasing vagal tone, ie performing “vagal manuevers” such as carotid sinus massage or putting pressure on the eyeballs. Calcium channel blockers such as diltiazem are often administered to break the SVT.

**Supraventricular Premature Contractions**
SVPC’s are the components of supraventricular tachycardia when they occur singly or in small groups. They originate the same as SVT from ectopic foci in the atria.

**Ventricular Premature Contractions**
VPC’s are premature beats that originate from foci within the ventricles. Multiple foci will lead to VPC’s with different structure, termed multifocal VPC’s. VPC’s are usually followed by a pause, before the next sinus beat. Therefore the R-R interval of the sinus beat to the VPC is shorter, than the R-R of the VPC to the following sinus beat.
VPC’s can be caused by heart pathology, myocardial hypoxia, following myocardial trauma (common following HBC), they can be associated with pain, acidemic states, and the use of some drugs. Typically, VPC’s are treated with lidocaine, and if this is ineffective, procainamide.

**Ventricular Tachycardia**

Ventricular Tachycardia is defined as runs of 3 or more VPC’s in a row. This is a very common arrhythmia in veterinary patients, and every technician should be very familiar with it. It is rapid, often between 150-300 bpm.

V-tach is characterized by wide, bizarre QRS complexes, without an obvious P-wave. The rhythm is usually regular, and there is usually marked reduction in cardiac output. This is evident especially when measuring direct arterial pressures, as you can often see the pulse waves disappear altogether.

There are several criteria for treating V-tach. Some runs of VPC’s and slow V-tach may go untreated, however it is important to know what point you should treat. There have actually been studies done that have found that treated VPC’s/V-tach may cause increased mortality, so, we do want to be cautious with treatment. It has been found that lidocaine and procainamide can be proarrhythmic as well as antiarrhythmic. The concern can be that some forms of untreated V-tach can move into ventricular fibrillation, our next topic.

So, at present, the criteria are simply: Treat if:

1. The patient is symptomatic: ie the patient has markedly decreased cardiac output causing syncope or organ dysfunction
2. The rhythm is at risk of becoming V-fib

**Ventricular Fibrillation**

V-Fib is a very interesting rhythm and is an arrest rhythm. In dogs, it rarely occurs spontaneously, and it is estimated that only about 10% of arrests fibrillate, compared to close to 50% in humans. V-fib is recognized by its complete erratic rhythm with no discernable, or identifiable waveforms. In fact, it is not uncommon for inexperienced persons to assume there is a problem with the ECG connections. Therefore, as always, it is advisable to assess the patient before the machine!
Learning Objectives:
1. Understand the specific focus of veterinary technicians in pain management
2. Develop “team” approaches to pain management
3. Discuss non-pharmacological modes of pain management

Veterinary technicians are in many cases the primary caregivers in veterinary clinics. This lecture will concentrate on recognizing pain through a series of videos using classic examples, and many that are much more subtle. We will then discuss methods for differentiating pain versus dysphoria. We will have an overview of frequently used analgesics, multi-modal analgesia, and briefly discuss the pharmacology and synergies between classes of drugs. Finally, we will discuss constant rate infusions and run through some example calculations.

Some important things to remember:

1. Mild to severe pain must be managed. Critical patients may be painful due to many causes including trauma, surgical pain, or inflammation.
2. Analgesics do not mask other signs!! Please don’t allow anyone to tell you that a patient is not a pain medication candidate because we don’t know what is wrong yet. If there are obvious signs of pain, it should be treated, and once the pain is relieved, it will often allow you to focus on the cause of other abnormal signs. Some people like to say that pain can mask other signs. Always treat pain!
3. Pain can be transient (ie abdominal cramping) or persistent
4. Important to be able to recognize pain, and when the animal is painful
5. A good pain scoring system incorporates abnormal parameters with patient behaviour

Let’s now consider the types of drugs we have available to manage pain in veterinary patients:

Types of analgesics

1. Opioids: generally considered the safest and most effective analgesic drugs
   - µ-receptor agonists (morphine, hydromorphone, fentanyl) the big guns
   - Agonist-antagonist (butorphanol) – for mild pain
   - Partial agonists (buprenorphine) – for mild to moderate pain
   - Antagonist (Naloxone reversal agent)
2. NSAIAS: Non-steroidal anti-inflammatory analgesics (Non-control)
   - Meloxicam
   - Etogesic
   - Carprofen

3. Non-opioid analgesics
   - Ketamine
   - Alpha-agonists (medetomidine)
   - Lidocaine

Some more important things to remember include:

**Titrate opioids to effect**

First let’s consider how an opioid works. There are receptors on the nerve fibers, called opioid receptors. These receptors are known as mu, delta, kappa and sigma receptors. These same receptors are found in the brain. When an opioid attaches to the receptors (most opioids target the mu and kappa receptors) along the nerve fiber, they act to block the pain sensation from reaching the brain, where it is perceived as pain. These same drugs attach to the receptors of the brain, which can lead to unwanted side effects such as dysphoria. When a patient is in a dysphoric state: characterized by vocalization, anxiety, restlessness, it means that they have too much opioid on board.

The goal in titrating opioids is to simply bolus small portions of the “dose”, wait a few minutes for a response, and then titrate in a little more if the response is positive (pain seems to lessen). We then stop titrating when we have reached a point of adequate analgesia, without dysphoria.

**If in doubt…**

If we are unsure of whether an animal is painful or not, err on the side of caution, and begin to titrate their dose of opioid. If their condition improves, continue to titrate until you are happy with their analgesic level, if they worsen, stop titrating. In some cases you can say without a doubt they are painful or dysphoric, however sometimes we have a hard time differentiating the two.

**Assume an animal is painful**

Rather than assuming the surgery wasn’t painful or the condition is not painful, work on the theory that the patient is painful and treat accordingly. We often underestimate the pain level a surgery is expected to cause, and often to do not take into account individual considerations. If
in doubt, ask for orders of an opioid and titrate it to effect. There is nothing worse than assuming based on prior experience that a procedure is not painful...can you honestly say that castrating, or spaying is not painful? Hello? Anyone had a laparotomy? Ouch!!

**Avoid wind-up and hyperalgesia**

Wind-up is a phenomenon that occurs quite frequently in critical patients and patients that are under-pain-managed. Essentially what occurs is the nerve receptors reset themselves with chronic unmanaged pain to such a point that a much lesser stimulus will cause worsening pain. This phenomenon is well documented in veterinary patients, probably because historically, they have been undertreated for pain.

By assuming that an animal is painful, and titrating opioid to effect, we can minimize wind-up. We are always getting patients referred to us that are so wound up, that simply controlling their pain level and reversing the wind-up can take a week of multi-modal analgesia. These are the cases where it is easy to say that the patient is not very stoic, however their pain is real...it may not be what we would typically consider painful, ie a patient may be incredibly painful from a simple touch...but it is real to them and must be treated accordingly. The nerve receptors can once again be reset to their normal level following appropriate analgesia, however it is much better to preempt pain and avoid this phenomenon.

If you work in a practice that does not have 24 hour care, or perhaps where the technicians are not very well trained in analgesia, it is important to provide intermittent bolus dosing of opioids to ensure that they are not painful when they are not being watched closely. It is probably better to have a little dysphoria, rather than to risk a lot of pain.

**Minimize anxiety and anticipatory pain**

It is not always enough to control the pain; we often have to treat a patient's anxiety as well. Often this requires the use of a sedative or tranquilizer in addition to our pain management. Anticipatory pain fits in with wind-up to a certain degree, and occurs when the patient is used to pain being associated with our procedures. It is important to keep this in mind and provide preemptive analgesia prior to performing painful procedures. In some patients, this may be as simple as changing their body position, taking blood, etc. Anticipatory pain can be dangerous, as this can make a patient aggressive...it is better to think ahead and minimize it!
**Frequent boluses? Move to a continuous rate infusion (CRI)**

If you find that your patient requires frequent boluses of opioid, placing them on a CRI of an opioid will provide a much better level of analgesia. This also prevents the ups and downs we tend to see with bolus dosing... the patient becomes dysphoric at first, then more painful as the bolus wears off.

CRI's of opioids are commonly morphine, hydromorphone, or fentanyl. Fentanyl is a short acting drug which can be easily turned up or down as necessary, allowing for a better analgesic plane.