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International Society of Feline Medicine

Practical recommendations on the measurement of indirect blood pressure in cats



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Introduction

Hypertension is a common clinical problem in cats, most frequently diagnosed in older cats (above 7-10 years of age), but still often overlooked. In some studies, hypertension has been diagnosed in more than 5% of apparently healthy older cats.

The majority of hypertensive cats have an underlying disease that predisposes to the condition, and chronic kidney disease (CKD) is the single most common of these, with studies suggesting between 20% and 35% of cats with CKD may have hypertension

A diagnosis of hypertension may be suspected when a cat has a predisposing underlying disease (such as CKD, hyperaldosteronism, hyperthyroidism) or on the basis of clinical signs associated with so-called target organ damage (signs present in organs that are recognised as being susceptible to the effects of systemic hypertension) such as:

- Hyphaema
- Sudden onset blindness (retinal detachment)
- Hypertensive retinopathy
- Left ventricular hypertrophy
- Neurological signs

Ideally, hypertension should be diagnosed and managed before systemic effects occur, so blood pressure measurement of at-risk cats (including older cats and those with associated diseases) is strongly recommended on a routine basis.

It is generally considered that if systolic blood pressure is less than 150-160 mmHg, then the risk of target organ damage is mild to minimal, whereas if systolic pressure is consistently greater than 180 mmHg the risk becomes severe. However, interpretation of blood pressure measurements should take into account the individual cat, risk factors for hypertension, and the circumstances under which blood pressure was measured. It is important to exclude so-called white-coat hypertension (temporary elevations in blood pressure due to stress) to avoid treating cats unnecessarily, and this is a common and important issue in cats.

This booklet provides recommendations from the International Society of Feline Medicine on the practical measurement of blood pressure in conscious cats in order to make these measurements as accurate and reproducible as possible. Four short videos are also available to accompany these recommendations and illustrate the techniques involved.

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Recommendations

Procedures: Background, methods, patient and environment considerations



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Background

Hypertension (both primary and secondary to other diseases such as chronic kidney disease - CKD) is a common disorder, especially in older cats, but the evaluation of blood pressure and the diagnosis and monitoring of hypertension are complex. Indirect blood pressure measurement is the only acceptable method of assessing blood pressure in conscious cats, but this is as much an art as a science.

The two commonly used techniques for indirect blood pressure assessment are the Doppler and oscillometric methods. In general, the Doppler method has been regarded as more accurate (more closely representing true or direct blood pressure readings) in conscious cats, but newer generation oscillometric equipment (especially newer high definition oscillometric - HDO - machines) also appear to have acceptable accuracy for measuring systolic pressures in conscious cats.



CAT+ Doppler and VetHDO Blood pressure monitors



Whether Doppler or oscillometric equipment is used to assess blood pressure, measurement of systolic blood pressure (SBP) in cats is considered adequate for clinical assessment, as isolated diastolic hypertension appears to be rare. However, because blood pressure assessment can be affected by so many variables (including the operator, the conditions and environment the procedure is performed in, the equipment used, the position of the cat, and the site of measurement) it is important to use

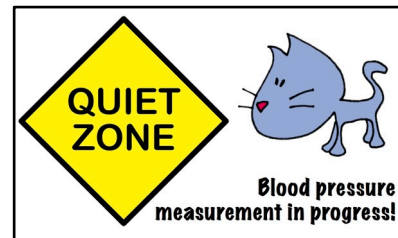
standardised protocols to reduce external variables as much as possible, but once mastered, blood pressure measurement can be a relatively quick procedure in many cats.



Recommended protocols

Systolic blood pressure is labile and will vary considerably both within and between individuals. Using a standardised protocol (as recommended by the American College of Veterinary Internal medicine (ACVIM) in their consensus guidelines - JVIM 2007;21:542–558) will help to reduce the effect of external influences on blood pressure and make measurements more clinically reproducible and reliable. These recommendations, adapted from the ACVIM consensus guidelines, are recommended for use in cats:

1. **Environment:** It is essential to assess blood pressure in a calm, quiet environment. This should be away from other animals, with minimal personnel, with no other procedures occurring at the same time and with no interruptions. The choice of room will depend on clinical needs and circumstances - it may (for example)



be in a consultation room, in a procedures room, in a hospital ward or in the home environment. In some situations it may be possible to measure blood pressure in a hospitalised cat while it remains calm and comfortable in its cage in the hospitalisation ward. However in

general blood pressure should be assessed while the cat is away from other animals, never in the same room as a dog, and away from noise, lighting or smells that may contribute to stress. Try to have the cat resting on bedding which it is used to and which contains its own scent. The use of Feliway® in the environment or on the bedding may be valuable.



2. **Acclimatisation:** A minimum of 5–10 minutes should be allowed in the environment (room) for the cat to acclimatise before blood pressure is measured. The cat should be free to explore the environment and interact with people in the room if it chooses to, but should not be forcibly removed from the carrier. A carrier with a removable top can allow the cat to stay in the bottom of the carrier, where some may feel safer.



3. **Personnel:** The people present in the room during the acclimatisation period should be the same people that will be present during measurement of the blood pressure. Blood pressure should be measured by a trained individual, and using a veterinary nurse or technician who is empathetic with cats is often desirable. When measuring blood pressure in cats seen as outpatients, it is often preferable to have the owner present to reassure the cat in a quiet, gentle way.

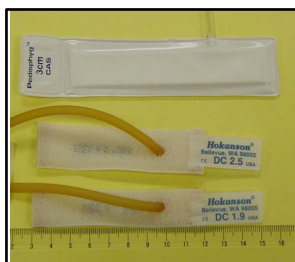
4. **Restraint:** It is vitally important that minimal and gentle restraint is used in order to keep the cat in a settled, comfortable position. If the cat becomes agitated during the procedure, it is better to stop and take a break to allow the cat to settle down rather than persist with more active restraint. Where appropriate, owners may assist with reassurance and gentle restraint of the cat – having comfortable and familiar bedding for the cat to rest on will be helpful.



5. **Positioning the cat:** Where possible the cat should be allowed to relax in a comfortable posture – lateral or sternal recumbency, sitting or standing. The cat should not be restrained in lateral recumbency but if he or she chooses to lie in this position that is fine. It is best to attempt to keep the cat in the same position throughout the procedure and to avoid measuring blood pressure while the cat is moving.



6. **Choice and position of cuff:** For cats, the correct cuff width is 30–40% of the circumference of the site where it is being applied (forelimb, hindlimb or tail). An incorrect size will lead to false elevation (if too small) or false lowering (if too large) of the measured blood pressure.



Blood pressure can be measured on any limb or on the tail - the forelimb may be easier and more reliable for Doppler, and the tail may be preferable for HDO. Care may also be needed in manipulating limbs of older arthritic cats in particular. Where possible, the site of blood pressure measurement should be roughly on the same horizontal plane as the heart. More expensive cuffs are generally better and easier to use than cheaper ones!

7. **Measuring blood pressure:** Before measuring blood pressure it may be advisable to inflate and deflate the cuff a few times to get the cat used to the sensation.



Always discard the first SBP measurement and then record 5–7 consecutive and consistent (<20% variability between readings) measurements. If there is a consistent downward (or upward) trend in the individual SBP readings, further measurements should be undertaken (possibly after giving the cat a break) until consistent readings are achieved. The mean of 5-7 consistent recordings can then be calculated to give the final SBP. If necessary, the procedure should be repeated to achieve consistent individual readings, keeping the cat calm and still, and changing position and placement of the cuff if necessary. If less than 5-7 readings are available but they all suggest a consistent blood pressure well within the normal range, additional measurements may not be

necessary (especially if the cat is becoming agitated). However, if there is any doubt about the validity of the measured SBP, regardless of the number of measurements, the procedure should be repeated - either immediately, after a further period of quiet acclimatisation, or at a later time point.

8. **Written records:** Careful records should be kept of all important aspects of the blood pressure measurement (see example) ... these should include date, time, environment, people involved, position of the cat, size of the cuff, site of cuff placement, equipment used, individual SBP measurements, and calculated mean SBP.
9. **Consistency:** Where repeat blood pressure assessments are being performed over time, for the purposes of meaningful comparison, it is important to try to replicate the assessment using the same equipment, personnel and procedures as far as possible each time.

isfm Blood Pressure Assessment Form				
Date: _____ Time: _____				
Cat's name: _____ Owner details: _____				
Age: _____				
Sex: _____				
Weight: _____				
Body Condition Score: _____				
Position of the cat:				
<input type="checkbox"/> Sitting	<input type="checkbox"/> Sternal recumbency			
<input type="checkbox"/> Lateral recumbency	<input type="checkbox"/> Standing			
<input type="checkbox"/> Other (specify): _____				
Position of the cuff:				
<input type="checkbox"/> Right forelimb	<input type="checkbox"/> Right hindlimb			
<input type="checkbox"/> Left forelimb	<input type="checkbox"/> Tail			
	<input type="checkbox"/> Left hindlimb			
Equipment used: _____	Size of cuff: _____			
Location (room): _____	Owners present: _____			
Performed by: _____				
Subjective assessment of stress: _____				
Record of all SBP measurements (mmHg):				
1. _____	3. _____	5. _____	7. _____	9. _____
2. _____	4. _____	6. _____	8. _____	10. _____
Mean SBP (mmHg) (takes through readings that are ignored and takes mean of the remaining values): _____				
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Blood pressure assessment with the Doppler technique



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A variety of different Doppler machines are available to measure blood pressure in cats including the CAT+ Doppler (Thames Medical), Vet-Dop2 (Vmed Technology), and the 811-B Doppler (Parks Medical). These are all used in a similar way and have been shown to be reliable in measuring blood pressure in conscious cats.



As always when measuring blood pressure, it is important to minimise stress, use a quiet room, keep the cat away from other animals and noise, and allow at least 5-10 minutes for acclimatisation to the environment (see previous section).

In some situations and with a relaxed cat, it may be possible to measure blood pressure single-handed. However, in practice, it is often preferable to have two people so that one can gently hold and reassure the cat.

Where to measure blood pressure

Blood pressure measured with the Doppler technique is usually performed using the forelimb or tail, although a hindlimb can also be used. There is evidence that the forelimb is generally tolerated better and is easier and quicker in most cats.



On the forelimb, blood flow is detected (with the Doppler probe) in the common digital artery between the carpal and metacarpal pads, the inflatable cuff being placed below the elbow. On the tail, blood flow is detected in the coccygeal artery (on the ventrum of the tail) and the cuff is placed around the tail base.



Selecting cuff size



The circumference of the limb or the tail at the site where the cuff is to be placed should be measured. The ideal width of the inflatable cuff used should be 30-40% of the measured circumference. A cuff width of around 2.5cm is suitable for most cats, but the tail/limb circumference should be measured and recorded for each cat.

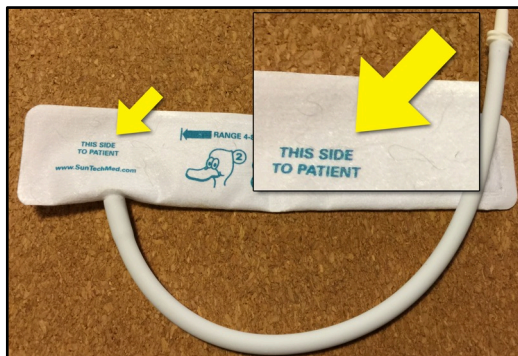


Should you clip the hair?

To detect blood flow in the artery, it is important there is excellent contact between the Doppler probe and the skin. This is achieved with the use of alcohol to dampen the hair and skin and the use of ultrasound coupling gel (see below). Clipping the hair at the site where the probe is used is not necessary, but some prefer to do this as it can make detection of blood flow easier. If done, use quiet, gentle, cat-friendly clippers, and allow the cat time to settle down after the hair has been clipped.

Placing the cuff

The cuff, with the inflatable side towards the skin, should be placed around the forelimb or tail and should fit snugly, but not be too tight. If the cuff has only a short inflatable section, make sure this part is positioned over the artery to be occluded. The cuff is usually secured in place with a Velcro fastener - if needed a small piece of adhesive tape may be used in addition, but this should never be wrapped around the limb. The tubing from the cuff is attached to the sphygmomanometer. Before use, check the cuff for leaks (inflate it, and check it does not spontaneously deflate).



Prepare the skin and Doppler probe



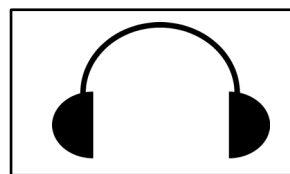
To ensure good contact between the Doppler probe and the skin, first dampen the hair and skin (at the site the probe will be applied) with a cotton wool swab soaked in alcohol.

A liberal quantity of ultrasound gel should then be applied to the hair between the carpal and metacarpal pads, or the ventrum of the tail, where the probe will be used. The gel should be massaged in so that the hair and skin becomes completely saturated with gel. A small amount of gel should also be applied to the Doppler probe.



Use headphones!

Always use headphones - have these plugged in before turning the unit on to avoid sounds from the Doppler unit disturbing the cat.



Measuring blood pressure with the Doppler

The Doppler probe is positioned between the carpal and metacarpal pads or over the ventrum of the tail, and held with gentle pressure. Excessive pressure (that restricts blood flow) should be avoided, but gentle pressure is needed to ensure good contact and a good signal.

The position of the probe is carefully adjusted until pulsatile blood flow can be heard from the common digital artery (forelimb) or coccygeal artery (tail). If a signal is difficult to detect, applying more ultrasound gel may be helpful.



Measuring systolic blood pressure (SBP)

Once pulsatile blood flow is detected, the Doppler probe should be gently held in place, avoiding any movement. The sphygmomanometer is then inflated by gently squeezing the compressible bulb. Watch the pressure on the dial of the sphygmomanometer, and inflate to around 20-40 mmHg above the point where blood flow is no longer heard.



Air is then allowed to slowly bleed from the valve at the back of the sphygmomanometer (usually a trigger- or screw-valve). The air must be released slowly, and the systolic blood pressure (SBP) is the reading when return of blood flow is first detected (first heard).

The first SBP reading is usually discarded, as the cat needs to become accustomed to the procedure. SBP should be measured five to seven times subsequently (allowing the cuff to deflate completely between each and then repeating the procedure as above).

If the Doppler signal (blood flow) is lost, the probe may need repositioning. If the cat becomes agitated, stop and allow the cat to relax before starting again. The aim is to get 5-7 readings that are all consistent (<20% variation) and the SBP is taken as the mean of these readings. Fewer (3-5) readings can be acceptable, but more readings increase the accuracy of the data. Sometimes several initial readings may have to be discarded if there is a consistent drop in SBP (eg. due to initial stress).

All readings, patient and procedure information should be recorded.

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Blood pressure assessment with the HDO technique



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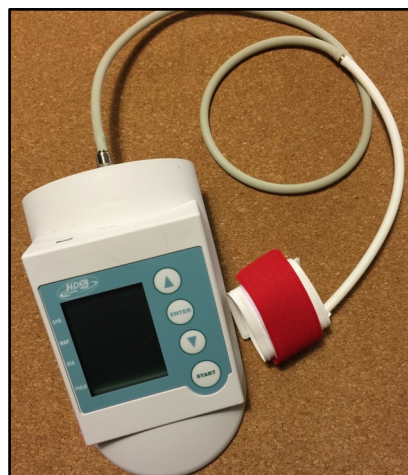
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High definition oscillometry

While Doppler has been used for many years for the indirect measurement of blood pressure in cats, and has been shown to have acceptable accuracy in a number of studies, traditional oscillometric units were regarded as generally unreliable in conscious cats with poor accuracy and sometimes being unable to generate a valid reading.

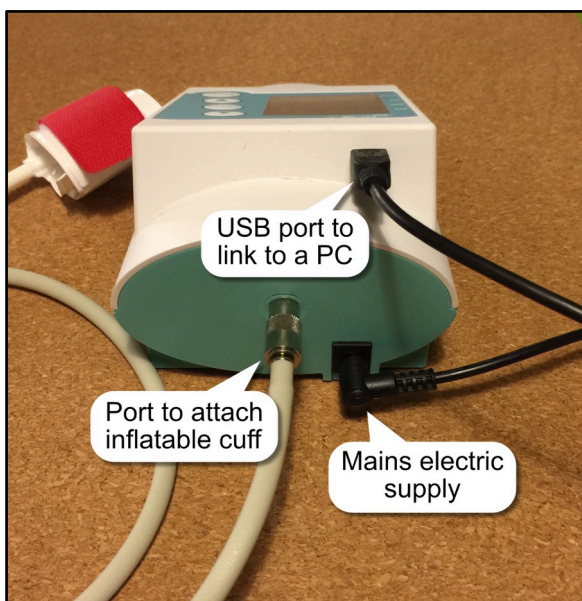
The more recent introduction of high definition oscillometry (such as the VetHDO, S+B medVet) has overcome many of the problems associated with traditional oscillometry and in published studies has been shown to provide an accurate assessment of systolic blood pressure in conscious cats.



Advantages and disadvantages

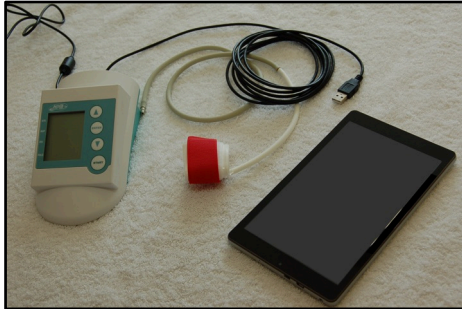
In general the HDO equipment is a little easier to use than the Doppler. HDO will also provide a measure of diastolic (DBP) and mean arterial pressure (MAP) in addition to systolic pressure (SBP) - while potentially helpful, DBP and MAP readings may in fact be much less accurate than SBP with HDO, and isolated diastolic hypertension is regarded as rare in cats.

Compared with Doppler, HDO is more expensive to purchase, and also it is strongly recommended that the HDO machine is always linked to a PC or tablet computer while measuring blood pressure. Connecting the HDO to a PC allows visualisation of the recording, which is important as movement or other artefacts can lead to false blood pressure readings. Using the HDO without a PC may give spurious results without the operator being aware.



Because patient movement can readily cause false readings, it is recommended that the cuff be applied to the tail when using HDO in cats, and to keep the cat as still as possible. However, the cuff can also be used on the limbs if needed.

Patient preparation

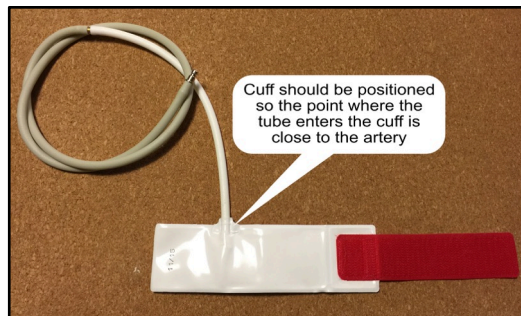


As with any technique, when measuring blood pressure it is important to minimise stress. Use a quiet room, keep the cat away from other animals and noise, and allow at least 5-10 minutes for acclimatisation to the environment (see earlier section).

In some situations, it may be possible to measure blood pressure single-handed. However, in practice, it is often preferable to have two people so that one can gently hold and reassure the cat. The HDO machine should be linked to a PC or tablet (via a USB cable or via Bluetooth, depending on the unit).

Cuff positioning

In general the HDO equipment comes with a single size cuff for cats and so long as it is well tolerated, this should be used on the tail, as this is easier and less likely to result in false readings from movement artefact. If more than one cuff size is available, the circumference of the tail at the point where the cuff is to be placed should be measured, and a cuff width selected that is 30-40% of that circumference.



The cuff should be positioned so that the area where the inflation tube enters the cuff is placed ventrally on the tail (close to the coccygeal artery) as this maximises the sensitivity of the HDO. As with Doppler, the cuff should be checked for leaks before use.

The cuff should be applied snugly around the base of the tail and secured with the Velcro fastener - it should be tight enough to stay in place but not so tight as to cause constriction of the tail. In some cats, once the cuff has been placed, they may be happy to curl up or lie in a basket or bed without any further restraint or interference.

Measuring blood pressure

Once the cuff is in place and the cat is comfortable, the machine can be turned on and blood pressure recordings can begin. First check the settings on the machine are correct though (for example, that the correct cuff size has been entered into the machine).



The PC or tablet should also be connected, and the software loaded to enable computer recording and display to take place.

When a blood pressure reading is initiated (by pressing the 'Start' button on the HDO machine), the cuff will automatically inflate and then deflate at a constant speed. The blood pressure (SBP, MAP and DBP) will subsequently be shown on the display along with the heart rate. This will also be shown on the PC along with a visual trace.

The first blood pressure reading should be discarded as the cat acclimatises to the inflation and deflation of the cuff. Subsequently, 5-7 further blood pressure readings should be taken. Additional measurements should be made if these are not consistent (<20% variation) or if there is a trend for lower measurements over time (suggesting the cat was stressed).

The mean of 5-7 consistent readings is taken for SBP (and for DBP and MAP). If the cat becomes restless, agitated or starts moving, take a break, allow the cat to settle, and then start again.

In some cats, if they are very relaxed and not moving much, it may also be possible to use a forelimb to measure blood pressure, placing the cuff below the elbow.

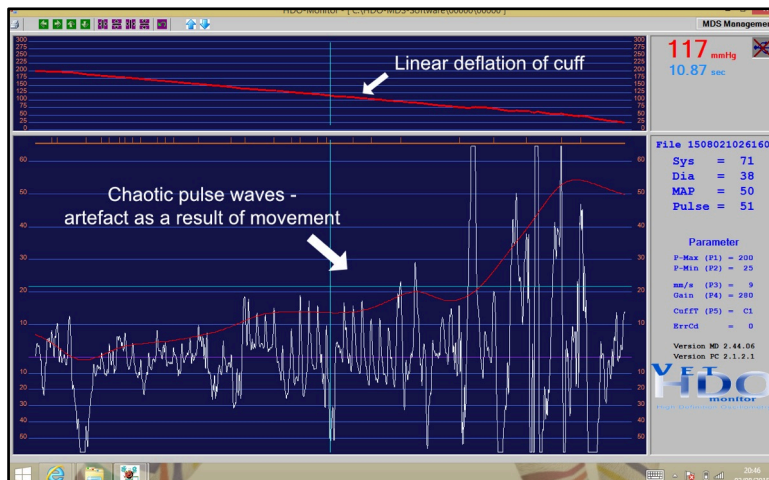
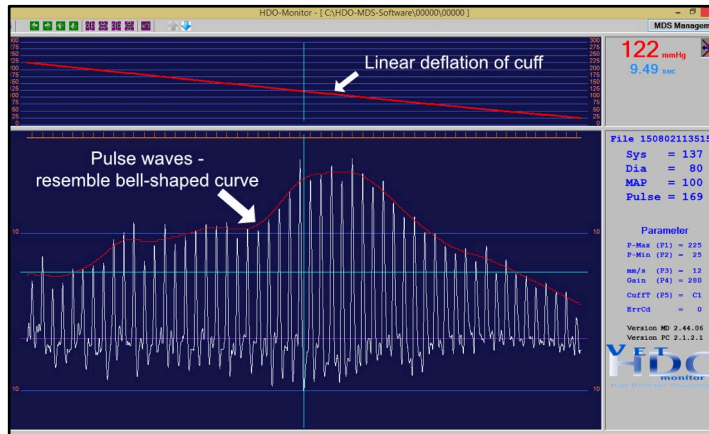
With each blood pressure reading, it is important to take notice of the PC reading and the curves displayed to assess whether the reading may have been affected by movement or other artefact (see below).



Checking for artefacts with the PC or tablet

When linked to a PC, with each set of readings from the HDO monitor, along with storing the data, a visual display is shown of the deflation of the cuff (top line) and the pulse waves detected (bottom curve).

The top line should be checked to ensure it displays a steady constant deflation of the cuff, and the pulse waves should generate a pattern that approximates a bell-curve.



If the above criteria are not met (most commonly the pulse waves will show significant distortion) the reading should be discarded as movement or some other artefact may have affected the accuracy of the blood pressures recorded.

This step should not be ignored, as the machine will often not detect errors associated with movement.

All readings should be recorded (along with other patient and procedure information). Note studies suggest that while the SBP is accurate, the DBP and MAP measured by HDO may be inaccurate in cats.

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Blood pressure assessment form







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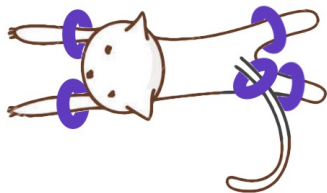


Date		Time	
Cat's name		Owner details	
Age			
Sex			
Weight			
Body Condition Score			

Position of the cat

 <input type="checkbox"/> Sitting	 <input type="checkbox"/> Sternal recumbency	 <input type="checkbox"/> Lateral recumbency	 <input type="checkbox"/> Standing
<input type="checkbox"/> Other (specify):			

Position of the cuff:

<input type="checkbox"/> Right forelimb		<input type="checkbox"/> Right hindlimb
<input type="checkbox"/> Left forelimb		<input type="checkbox"/> Tail <input type="checkbox"/> Left hindlimb

Equipment used		Size of cuff	
Location (room)		Others present	
Performed by			

Subjective assessment of stress:

Record of all SBP measurements (mmHg):

1.	3.	5.	7.	9.
2.	4.	6.	8.	10.
Mean SBP (mmHg) Strike through readings that are ignored and take mean of the remaining values				

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For videos go to:
www.youtube.com/icatcare
and search for 'blood pressure'

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