PRACTICAL ECG

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Why Vetronic Services?

- Passion for electronics
- Wanted to produce products that would make my life easier in everyday practice life e.g.
  - Quick reliable ECG monitors
  - Simple to use ECG diagnostic equipment that could be used for monitoring as well as a full diagnostic ECG workup
We’ve come a long way

Augustus Desire Waller 1856 - 1922
Procedure for ECG 1920
Monitoring & Diagnostic ECG

There are big differences between a monitoring ECG and a diagnostic ECG
- Monitoring ECG’s are heavily filtered
- Lower sampling rate for monitoring ECG
- Diagnostic ECG equipment can be used for monitoring but cannot use a monitor ECG for diagnostic work-up
Diagnostic ECG

Three steps to performing a basic ECG investigation

– Get a good clean tracing
– Make rapid reliable measurements
– Interpretation based on the trace and clinical observation
Getting a good clean ECG Trace

- The Equipment
- Methods of attachment
- Assessment
Equipment Selection

- Equipment needs no introduction
- Mains or battery?
- Some explanation needed regarding merits of single lead versus 6-lead
- ECG Cable selection
  - unshielded versus shielded
  - UK versus USA colour coding
- Analog versus digital – some analog machines are actually relatively poor digital types
Mains or Battery

- Both is ideal but Battery is the optimal option.
- Biggest problem with ECG taking is mains interference.
- Even on some of the expensive ECG machines there are noticeably better results when run on the battery.
- Invariably have cables running across the machine – susceptible to mains pick up.
Single Lead Versus Six-lead

Nomenclature

- “Lead” refers to the Bipolar leads e.g. Lead II
- A “Lead” requires 2 connections and a reference connection
- A Single Lead machine has 3 cables
- A Six Lead machine has 4 cables
Single Lead versus Six Lead

- With a Single Lead machine you can only look at one Lead at a time
- You cannot therefore look at magnitudes of complexes in different leads at the same time
- This limits the clinical information that can be gained e.g. eliminating noise/movement, or calculating Mean Electrical Axis
- But a good quality single lead machine is still very useful
ECG Cable selection

- Shielded or unshielded
- Makes a lot of difference to the ability to obtain a good ECG
- Many medical ECG cables are shielded only as far as the split. After that the cable is unshielded
- Susceptibility to mains interference is greatly increased.
Colour conventions

- Different between UK and USA
UK Lead convention

- RED – Right Fore
- YELLOW – Left Fore
- GREEN – Left Hind
- BLACK – Right Hind (reference electrode)
USA Lead convention

- RED – Left Hind
- WHITE – Right Fore
- BLACK – Left Fore
- GREEN – Right Hind (reference electrode)
Equipment Types

- Analog
- Digital

Probably today there is very little difference between them.

In fact most are now digital even though they are referred to as analog.
Analog versus digital

- If it doesn’t have an analog stylus it isn’t truly an analog machine
- The rest are digital – thermal print heads that have a fixed resolution of around 200dpi
Analog??

- E.g. the Nihon Kohden 8400 series
  - Uses a 203 dpi thermal head
  - 203dpi gives 400 steps on standard ECG paper. This is only slightly better than the worst 8-bit ‘digital’ machines. 10 or 12-bit digital machines will have 4 or 8 x more resolution.
Analog ECG Machines

- True analog machines have a stylus
- They give good results with standard patients i.e. low heart rates
- Inertia of the stylus causes problems of overshoot and ringing with very fast heart rates – over 300 bpm – not suitable for exotic/avian work
Getting a good ECG Trace

- The Equipment
- Methods of attachment
- Assessment
Methods of attachment

Primary aims

- Maximise the surface area of attachment
- Minimise the contact resistance
- Minimise noise pickup
Maximise the surface area of attachment

Options
- Crocodile clips
- Sticky ECG electrodes
- Limb Plate Electrodes
- Hypodermic needles
Crocodile clips

- Can be painful
  - Use modified clips
  - ‘Bite’ as much skin as possible
    - Spreads the load
    - Reduces pain
    - Maximises the contact
  - Need a conducting medium
  - Much better with shaved area
Sticky ECG Electrodes

- Variety of sizes but the contact area is essentially the same
- Need well prepared dry skin
  - Clip area larger than ECG pad
  - De-grease with surgical spirit
  - Allow to dry and then apply pad
- Takes time to apply so good for long ops or ambulatory monitoring
- Can get reasonable results from the pads of the feet but skin resistance is high so subject to noise and movement artefact
- Good preparation is imperative otherwise get mediocre results
ECG Pad Types
Limb Plate Electrodes

- Very easy to apply
- Non painful
- Large surface area
  so good signal pickup
- No need to clip hair
- Good long term results (hours)
Limb Plate Electrodes
Hypodermic needles

- Fairly well tolerated – 21g or 23g
- Bypasses skin resistance but small contact area so can produce unreliable results, particularly with movement
- Good for e.g. birds where skin is very fragile and cannot use pads or LPE
- Push needle under skin and out again, then attach crocodile clip to free end – picture.....
Minimise contact resistance

- Hair provides distinct barrier to contact, even when soaked in spirit
- Remove hair – pluck or shave
  - Anaesthetised dogs/cats: Pluck hair between pads and use modified crocodile clip for quick connection
- For crocodile clips and LPE apply contact medium *before* attaching electrode
- Use a conducting medium
  - Surgical spirit/isopropyl alcohol
  - Electrolyte solution/Saline
  - Cardiac gel/Ultrasound gel (remove after use)
<table>
<thead>
<tr>
<th>Agent</th>
<th>Pros</th>
<th>Cons</th>
<th>Contact Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical Spirit</td>
<td>Promotes good contact. Cheap. Easily available</td>
<td>Smell. Irritant. Short contact time</td>
<td>10-15 minutes</td>
</tr>
<tr>
<td>Isopropyl Alcohol</td>
<td>Promotes good contact. Reasonably cheap</td>
<td>Smell. Irritant</td>
<td>30-40 minutes</td>
</tr>
<tr>
<td>Electrolyte Solution, e.g. Signa Spray by Parker</td>
<td>Non-irritant. Good contact. Low/zero odour</td>
<td>Less readily available. Increased cost</td>
<td>1 hour+</td>
</tr>
<tr>
<td>Cardiac Gel</td>
<td>Good sustained contact</td>
<td>Less easily available. Increased cost</td>
<td>2 hours+</td>
</tr>
<tr>
<td>Self adhesive Electrodes</td>
<td>Clean. New contact every time. Simple to use</td>
<td>More expensive. Must prepare area. Not re-usable</td>
<td>2 hours+</td>
</tr>
</tbody>
</table>
Remove outer layer of dead skin

- Common practice in human medicine to abrade skin with emery-paper prior to attaching ECG electrode.
- Removing some of outer keratinised skin markedly reduces skin resistance
- Last resort for that patient that will not give a good ECG
Minimise contact resistance

Don’t even try with a set of clips like this
Minimise Noise Pickup

- So now you have a well attached ECG set of cables. Is that all you need for a good ECG?

- NO!
  - Must reduce noise pickup as well
Cable Position

- Cable position is extremely important
- Due to phenomenon of Common Mode Rejection
- Simply put – For best rejection of noise all leads must “see” the same interference
Common Mode Rejection

Mains interference

Flat Line output
Improving Common Mode Rejection

- Minimise contact resistance
- All leads should be same length especially if unshielded
- All leads should run as close together as possible
Effect of cable spread

The two pictures show the ECG of the patient with spread cables and with parallel cables.
Demonstration of effect of Cable Spread
Getting a good ECG Trace

- The Equipment ✓
- Methods of attachment ✓
- Assessment
- What can go wrong
- How to remedy it
So you can’t get anything but noise

What do you do?

Test the machine
Remove Causes of interference
Test the Machine

- Two very simple tests to assess the ECG machine
  - All Leads together
  - Individual Lead test
Test the Machine

- Two very simple tests to assess the ECG machine
  - All Leads together
  - Individual Lead test
All Leads together

On all Lead settings of the machine there should be a completely flat line. If not, there is a fault.
Individual Lead Test

Red Outline

Hold all four leads in one hand and fan out the clips
Individual Lead Test

- Touching any one of these leads (except Right Hind) should cause massive stylus movement or screen trace deflection.
- Touch each in turn. A properly functioning machine will have the following response.
Individual Lead Test

- **Lead I**
  - Response with Right Fore and Left Fore
  - No response with Left Hind or Right Hind

- **Lead II**
  - Response with Right Fore and Left Hind
  - No response with Left Fore or Right Hind

- **Lead III**
  - Response with Left Fore and Left Hind
  - No response with Right Fore or Right hind
Deducing a Lead problem from the ECG Result

Right Hind contact problem

Lead I

Lead II

Lead III
Deducing a Lead problem from the ECG Result

- Right Fore contact problem

- Lead I

- Lead II

- Lead III (Does not involve RF)
Deducing a Lead problem from the ECG Result

- Left Fore contact problem

Lead I

Lead II (Does not involve LF)

Lead III
Deducing a Lead problem from the ECG Result

- Left Hind contact problem

- Lead I (Does not involve LH)

- Lead II

- Lead III
Sources of interference

- Mains induced noise
- Movement
- Mobile phones
- Newer digital Cordless phones
Getting a good ECG Trace

- The Equipment ✓
- Methods of attachment ✓
- Assessment ✓
Dealing with Noise

- Try to avoid using filters whenever possible
- It will always alter the ECG to some extent. How much will depend on the filter and the characteristics of the ECG e.g. birds
Unfiltered AGP

Mains Filter

Muscle Tremor Filter
Make rapid reliable measurements

This is one area where digital technology takes over from older methods.

Measurements can be made very quickly and accurately on a digital system.
Parameter Measurement

- All our digital systems allow on-screen measurements with a mouse.
- Produces more accurate and faster results.
- All results are already on the computer, no need to add later. Simply save file with patient records.
Now armed with the array of measured ECG parameters you can begin the task of ECG interpretation.
Some helpful tools

From UC Davis web site
http://vetpda.ucdavis.edu/Projects/VetPDA-Calcs.cfm
From www.cvphysiology.com

Extremely readable and informative text with excellent descriptions
The End