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Doing the mathematics in critical care

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Introduction

- We will use a case based approach
- Each case will highlight one or 2 aspects of critical care
- I hope to pass on some practical tips on these as we discuss the cases.
- In each case YOU will be doing most of the work!

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Case one: history

A 53kg Newfoundland has undergone a lateral thorocotomy to investigate recurrent pleural effusion. A pericardectomy has been preformed and the thoracic duct ligated.

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Case one: current treatment

- Intra op fluid therapy
  - Hartmann's - 10ml/kg/hr
- Post op fluid therapy
  - Hartmann's - 3ml/kg/hr
- Draining thorax via chest drain q 2-4hrs
- Analgesia
  - morphine epidural pre op, local anaesthetic via soak catheter CRI and morphine boluses to control any 'break-through' pain.

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Case one:

- Passed urine once - about 2 hours into recovery.
- Has not been observed passing urine since then despite a good recovery and being able to walk out to the runs this morning.

Case One: Nursing concerns

- What are your nursing concerns and considerations?
  - _
  - _
  - _
  - _
  - _

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Case one: potential causes

- What in general terms might be the cause of this patient's failure to void urine?

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Case one: potential causes

- Reduced production
  - Renal failure
- Urinary retention
  - Behavioural
  - Failure of bladder contraction
- Unobserved urination
- Not recorded urination
- Urine in bedding etc.

Case one: additional information

- Bedding dry
- Abdominal palpation – very small bladder
- Eating and Drinking: minimal
- PCV 38% TP 54g/l (↓)
- Urea 19.5mmol/l (↑)

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Case one: additional information

- Volume from chest drain:

2pm:	200ml	4pm:	350ml
8pm:	475ml	mid:	n /r
4am:	450ml	8am:	425ml
Noon:	325ml	4pm:	275m

Case one: Nursing plan

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-
-
-
-
-

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Case one: possible cause

- Pre-renal renal failure
  - Small bladder,
  - small rise in urea,
  - ongoing losses of fluid
- Calculate fluid intake and losses

Case one: calculations

- Total losses from this patient:
  - 2500ml pleural effusion recorded
  - Probably 500ml+ more unrecorded
  - Panting may increase water losses above maintenance
  - Fluid will remain in thorax despite drainage
  - Ongoing maintenance
- Total fluid intake - 3ml/kg/hour

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Case one: calculations

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IN

IV fluids
3ml x 53kg x 26hrs = 4134ml

Total: 4134

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Case one: calculations

	OUT
Maintenance 2ml x 53kg x 26hrs =	2756
Pleural effusion =	2500
Estimated other losses =	1250
Total	6506

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Case one: Treatment

- This patient needs fluids!
- Replace deficit over 6-12 hours and match maintenance AND **ongoing losses**

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Case one: Treatment

- Deficit: 2372ml
  - Over 12 hrs this is 198ml/hr
- Add maintenance
  - 3ml/kg/hr = 159ml/hr
- Add ongoing losses
  - (estimated) 75ml/hr
- Total: 423ml/hr
- Review this frequently
  - at minimum every time chest is drained.

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Case one: conclusion

- Monitor patients closely
- Always consider fluid balance
- Make sure notes are kept up to date
- Make sure case orders have been regularly reviewed and updated

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Case two: History

- A 5.4kg nM cat presents late in evening surgery.
- He was off colour this morning resenting the family touching him and he was sitting in his litter tray (unusual for him).

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Case two: History

- When everyone came in from work he was still in the litter tray (which was dry).
- He has not eaten or drunk all day, growls when touched and is weak/depressed.

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Case two: examination

- Upon examination he has a distended painful abdomen
- Heart rate is 170bpm
- Femoral pulse weak

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Case two: Nursing concerns

- What are your nursing concerns and considerations?
  - _
  - _
  - _
  - _
  - _

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Case two: further diagnostics

- Not possible to palpate bladder even after 0.4mg/kg methadone for sedation / analgesia
- Ultrasound of abdomen failed to reveal an intact bladder
- Large volume of free peritoneal fluid seem
- Sample taken

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Case two: further diagnostics 2

- Test sample:

Visual appearance	off clear pale yellow
Blood urea dipstick	++++
Creatinine	765
Urea	45

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Case two: diagnosis

- Sample consistent with free urine in abdomen
  - Uroabdomen
  - Rupture of the urinary track

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Case two: Nursing plan

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-
-
-
-
-

Case two: concerns

- Painful
- Poor circulation
- Ruptured bladder
- Consequences of ruptured bladder
  - Potassium retention & Azotemia
  - Hypovolemia & dehydration
  - Peritonitis & Pain
  - Stress

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Case two: additional information

- PCV 67% TP 78g/l
- Na^+ 137mmol/l
- K^+ 8.9mmol/l
- BUN 42.4mmol/l
- pH 7.1

- IV catheter placed
- Exploratory laperotomy required

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Case two: treatment plan

- Treat hyperkalemia
- Restore circulating volume
- Restore urine output
  - Normalise azotemia
- (further diagnostics)
- Explore abdomen
  - repair of urinary tract

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Case two: treat hyperkalemia

- Options for treating hyperkalemia
  - IV dextrose ½ - 1 g/kg slow IV bolus
  - IV regular insulin ¼ IU IV followed by 1g dextrose infused over next 15 minutes and then maintain on dextrose supplemented fluids
  - IV bicarbonate 1-3mEq/kg

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Case two: treat hyperkalemia

- IV calcium 100mg/kg calcium gluconate slow IV to effect
  - Note: this will not correct the potassium level but will antagonise its actions on the heart in effect buying time to allow other treatments to work

Case two: calculations

- Calculate the dose of calcium, insulin and dextrose required for this cat.
- Insulin ¼ IU/kg
  100 IU / ml
- Dextrose 1g/kg
  50% solution
- Calcium gluconate 100mg/kg
  10% solution

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Case two: insulin

- 5.4kg x $\frac{1}{4}$ IU/kg = 1.35 IU
- 100 IU/ ml = 0.0135 ml !!
- Consider dilution:
  - Easier and more accurate to administer

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Case two: insulin

- Insulin dilution.
- 1ml insulin solution in 99ml saline concentration now 100IU/100ml = 1IU/ml
- 1.35 IU = 1.35ml

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Case two: Dextrose

- 5.4kg x 1g/kg = 5.4g of dextrose
- 1% solution = 1 gram of drug in 100ml solution
  = 10mg /ml
- Therefore a 50% solution = 50g / 100ml
  or 500mg / ml

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Case two: Dextrose

- We need 5.4g
  5.4g = 5400mg
- 500mg/ml
  5400mg / 500mg/ml
  = 10.8ml
- 100ml / 50g * 5.4g = <u>10.8ml</u>

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Case two: calcium

- 5.4kg x 100mg/kg
  = 540mg

- 10% solution = 10g / 100g
  or 100mg / ml

- 540mg / 100mg/ml = 5.4ml

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Case two: Restore circulation

- IV fluids
  - Colloid bolus or Crystalloid bolus
  - Crystalloid infusion
    - Maintenance
    - Deficit
    - On-going losses
- What Crystalloid?
  - Hartmann's
  - Balanced polyionic non acidifying

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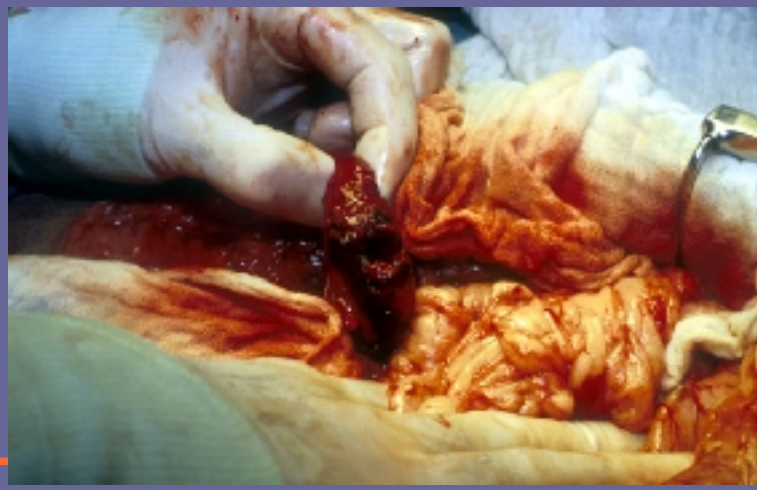
Case two: restore urine output

- Place a urinary catheter
  - Despite bladder rupture good drainage may be achieved
- Place an peritoneal drainage catheter
  - Under local anaesthetic
  - Single stab near umbilicus
  - Drain must be highly fenestrated
  - Oesophageal stethoscope makes good drain

Case two: conclusion

- Now WAIT!
- Ruptured bladder is an emergency – but rarely a surgical emergency
- Stabilise the patient first
- Then GA and explore
- Much safe anaesthetic



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Case three: history

- A known diabetic cat comes who has not been eating well for a few days
- Has eaten nothing since yesterday morning.
- Vomiting last night
- Now collapsed.

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Case three: further information

- Weight – 4.8kg
- A small bladder is palpated and a urine sample obtained.
- Ketone +++.
- A blood sample shows blood glucose to be *Hi*.

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Case three: nursing concerns

- What are your nursing concerns and considerations?
  - _
  - _
  - _
  - _
  - _

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Case three: Ketoacidotic crisis

- Diabetic ketoacidotic crisis
  - High glucose
    - But cells starved of glucose
    - Need insulin now
  - Acidotic
  - Ketone production
  - Potassium depletion (although serum levels may initially appear normal)
  - Phosphorus depletion (as with potassium may initially appear normal)

Case three: Plan

- What do we need to do?
  - _
  - _
  - _
  - _
  - _

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Case three: treatment plan

- Start insulin therapy
  - Hourly IM injections or IV infusion
  - Must use regular / soluble / neutral insulin
- Start IVFT at twice maintenance
  - Hartmann's – counteract acidosis & hypokalemia
- Check electrolytes
- Regular recheck blood glucose

Case three: additional information

- 1 hour after initiation of treatment

Na^+	138mmol/l
K^+	2.8mmol/l
Glu	28.9mmol/l

Case three: ongoing treatment

- Carry on insulin
- Supplement potassium
- Charts exist in many texts to act as a guideline

Serum K	Amount to add to 250ml
<2mmol	20mmol
2-2.5mmol	15mmol
2.5-3mmol	10mmol
3-3.5mmol	7mmol
3.5-5.5mmol	5mmol

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Case three: Calculation

- Potassium solution is 15% or 2mmol/ml
- How much potassium solution do we need to add to a 500ml bag of Hartmann's solution for our cat?
- Reminders

  Our cat K+ = 2.8mmol/l

  Chart says 10mmol/250ml of 0.9% NaCl

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Case three: supplementing K^+

- 10mmol in 250ml = 20mmol in 500ml
  - But Hartmann's already contains 4mmol/l
- 20mmol – 2mmol = <u>18mmol</u> required

- Potassium solution is 2mmol/ml
- 18mmol = 18/2 = <u>9ml</u>

of potassium solution needs to be added to our patient's fluid bag

Case three: recheck

- Glucose has been regularly checked every 4hrs overnight and insulin dose titrated as required
- Potassium was checked after 12hrs and had improved to 3.1mmol/l
- Now 24hrs since initiation of treatment
- Recheck K+ and phosphate

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Case three: recheck

- Recheck K+ and phosphate
  - K+ = 3.1mmol/l (low)
  - Phosphate = 0.61mmol/l (v low)
- IV phosphate supplementation should be given as slow infusion over hours – days
- Suggested rates of infusion
  0.01-0.06mmol/kg/hr

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Case three:supplement phosphate

- We will supplement this cat at 0.04mmol/kg/hr
- We have in stock potassium phosphate solution of concentration
  - 40mmol phosphate

  along with
  - 30mmol of potassium in 20ml

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Case three: calculations

- Weight - 4.8kg
- Phosphate rate - 0.04mmol/kg/hr
- Phosphate concentration
  - 40mmol / 20ml
- Potassium concentration
  - 30mmol / 20 ml
- Fluid rate - 15ml / hr

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Case four: Calculations

- How much concentrated solution should we add to a new 500ml bag of 0.9% NaCl?
- How much potassium will this mean we have added to the patient's fluids?

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Case three: calculations

- Weight - 4.8kg
- Phosphate rate - 0.04mmol/kg/hr
- Phosphate concentration
  - 40mmol / 20ml
- Potassium concentration
  - 30mmol / 20 ml
- Fluid rate - 15ml / hr

Case three: Calculations

- 4.8kg x 0.04mmol /kg /hr = 0.192mmol / hr
- Sice we are giving 15ml/hr we need 0.192mmol in each 15ml of fluid
- In a 500ml bag we need
  - 500 / 15 * 0.192 = 6.4mmol in the bag

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Case three: Calculations

- 40mmol phosphate in 20ml = 2mmol/ml
- 6.4mmol = 6.4/2 = 3.2ml
- This will also provide 3.2 x 30/20 = 4.8mmol K^+

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Case three: Calculations

- From the chart we need 7mmol/250ml
- 7mmol in 250ml = 14mmol/500ml bag
- We still need to add 14-4.8mmol= 9.2mmol or 4.6ml K^+ solution

Case three: conclusion

- Patients critical needs will change with time
- Regular reassessment and recalculation
- Consider the effect one treatment will have on other parameters and consider pre-emptive treatment
- Consider the effects of one drug on others being administered concurrently

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Case four: history

- Its that peskie Newfie again!
- 5 days post op.
- He is much happier.
- The chest drain is only yielding 100ml / drain every 4hours and the surgeon plans on removing it this afternoon.

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Case four: more history

- As the dog needs sedated for thoracic radiographs you weigh him.
- Weight – 47.5kg (53kg on admission)
- A check of his kennel sheet reveals that he didn't eat for the 1st 60hours post surgery
- Now has 'eaten' marked each morning and evening by his 'feed' box on the kennel sheet.

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Case four: Nursing concerns

- What are your nursing concerns and considerations?
  - _
  - _
  - _
  - _
  - _

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Case four: concerns

- Weight loss
- Possible causes
  - Reduced calorific intake
  - Increased metabolic demand
  - Increased losses
  - Reduction in pleural effusion volume
- Check body condition
  - Poor – and subjectively reduced since admission

Case four: concerns

- Uncertain food intake
  - Clinical records not descriptive of diet type / quantity
- Increased metabolism
  - Pain, disease and surgery can all increase metabolic demands for healing and as a consequence of physiological effects if stress

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Case four: concerns

- Increased losses
  - Chylous effusion is a fat rich solution
  - Also can have significant amounts of protein
  - Chronic problem likely to be ongoing weeks before surgery
- Reduction in pleural effusion
  - Each litre present at admission and subsequently removed will reduce weight by 1kg.

Case four: treatment

- Need to estimate nutritional requirements
  - Normally calculated at rest
  - Basal metabolic requirements
  - Then an extra amount is added to compensate for increased demand and ongoing losses
- Jury still out in veterinary medicine as to any benefit of specific dietary interventions

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Case four: calculations

- Calculate BMR
  - Several formula exist
  - Often requiring a calculator!
  - Some companies have produced useful reference charts
  - We will use

    = **(Weight * 30) + 70 kcal**
- For the weight – use ideal body mass

55kg in our patient

Case four: calculations

- For our dog
  (55kg* 30) + 70 = 1720 kcal

- Now have to convert this to meaning amounts of food!
  - This can be the hard bit – every looked at a can of dog food to see how many calories are in it…

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Case four: treatment

E.g. Sensitivity control

Dry - 336kkcal/100g

Canned - 534 kcal/can

- Our patient needs - 1720 kcal
  - How much food is this?
- Dry food:
- Canned:

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Case four: treatment

- Dry food:

  1720kcal/day / 3.36kcal/gram

  =

  512g / day

- Canned: 1720kcal / 534 = 3.25 cans / day

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- Also consider
  - Increased allowance for disease and stress
  - Maybe 10-20% increase
- If food intake has been below this level step intake up over several feeds & feed several smaller meals
- If poor appetite consider a more energy dense diet

Case four: Conclusions

- Nutrition is vital for success
- Accurate records and calculations – treat feeding as another 'medication' in the sick animal
- Consider force feeding at an early stage
- Weigh patients 1-2 times daily
- Modulate food intake according to weight trends

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Case five: history

- Toby has tetanus
- On presentation
  - able to stand
  - had characteristic pricked ears and sardonic grin
  - very stiff when trying to walk
  - could nor prehend or swallow food or water

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Case five: history

- Now
  - neurological status has deteriorated
  - recumbent
  - receiving sedation by continuous infusion of midazoalm and propofol to try and reduce the severity of his muscle spasms.

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Case five: concerns

- Nutrition
  - Place gastrostomy tube & feed
- Ventilation
  - place an arterial catheter to facilitate taking repeated arterial blood samples for blood gas analysis.
- Infection
  - Good nursing care!
  - Take care when feeding to reduce risks of regurgitation & aspiration

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Ventilation

- Monitoring blood gases
  - Look at CO2 and O2
- The normal CO2 = 40mmHg
- The 'normal' O_2 varies dependant on the concentration of O_2 in the inspired gas

Blood gas normals

- PaO_2 = 5 x the % of oxygen in the inspired gas
  - Room air 21% O_2
  - PaO_2 = 21 x 5 = 105mmHg
  - Nasal supplementation ~40% O_2
  - PaO_2 = 40 x 5 = 200mmHg
  - Pure O_2 via ET tube 100% O_2
  - PaO_2 = 100 x 5 = 500mmHg

Case five: blood gas

- 1st arterial sample
- PaO_2 78mmHg (breathing room air)
  - Pulse Ox - 94%
- $PaCO_2$ 34mmHg

Normals:

PaO_2 = Inspired O_2 x 5; $PaCO_2$ = 40mmHg

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Case five: treatment

- PaO_2 78mmHg (breathing room air)
- Room air = 21% O_2
- Anticipated PaO_2 = 21 x 5 = 105mmHg
- Therefore our patient is a little lower than we would expect.
- Try supplemental O_2

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Case five: blood gas

- 2nd arterial sample
- PaO_2 108mmHg (breathing room air)
  - Pulse Ox - 100%
- $PaCO_2$ 36mmHg

Normal:

PaO_2 = Inspired O_2 x 5; $PaCO_2$ = 40mmHg

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Case five: blood gas

- PaO_2 108mmHg (nasal O_2)
- $PaCO_2$ 36mmHg (normal = 40mmHg)
- Anticipated 40 x 5 = 200mmHg
- Still significantly below anticipated
  - Collapsed lung tissue
  - ? pneumonia
  - Reduced ventilation
  - Note pulse ox says 100%!!

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Case five: blood gas

- 12hrs later respiratory effort seems decreased and patient becoming tachycardic
- Blood gas sample taken
- PaO_2 68mmHg (nasal O_2)
- $PaCO_2$ 73mmHg

Normal:

PaO_2 = Inspired O_2 x 5; $PaCO_2$ = 40mmHg

Case five: blood gas

- PaO_2 68mmHg (nasal O_2)
- $PaCO_2$ 73mmHg (normal = 40mmHg)

- Anticipated PaO2 = 200mmHg
- Oxygenation getting worse
- PaCO2 is increasing
  - evidence of ventilatory failure
- Patient needs ventilated

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Case five: conclusion

- Pulse oximetery does not always give adequate information or warning of problems
- Supplemental O2 will help where diffusion is a problem
- Ventilation is required where O2 is falling and CO2 rising

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Questions?

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- **Thanks to our sponsors**

Remember the slides from this talk will be available on the 'net after the weekend.