Anaesthetic Emergencies

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South Tamworth Animal Hospital

Anaesthetic Emergencies

General anaesthesia poses minimal risk to most patients when performed by a capable anaesthetist using appropriate protocols and proper monitoring. However, it is vitally important that the anaesthetist remembers that every anaesthetic procedure has the potential to cause the death of the animal.

Anaesthetic emergencies: Prevention is better than cure

Fundamentals:
- Understanding Respiratory, Cardiovascular system and nervous system physiology and pathophysiology to enable knowledgeable patient monitoring and support of organ function are key to minimizing anaesthetic risk and assuring a good outcome
- Understanding the pharmacology of drugs used
- Understanding anaesthetic and monitoring equipment

Anaesthetic emergencies: Prevention is better than cure

31st May 1916 Battle of Jutland
6784 British killed and 3039 Germans

'Spinal anaesthesia is the ideal form of Euthanasia in war surgery'
Admiral Sir Gordon Taylor

Lessons from history: Thank you to Prof Eddie Clutton for the next 9 slides

Some 44 years later: the Korean war
"The only contraindication to this (spinal) form of anaesthesia is ignorance, because it provides unsurpassed Relaxation, rapidity of action, and quick recovery with a wide margin of safety". Donaghy G.E. Modern anaesthesia for war surgery Milli Surg 86: 577 - 581, (1960)

Lessons from history: Thank you to Prof Eddie Clutton for the next 9 slides

Hypovolaemic and shocked patients are in part protected from the deleterious consequence of their injury because of sympathoadrenal system activation. Local anaesthetics applied to the spinal cord block not only the somatic nervous system but also the sympathetic nervous system thus giving rise to a profound vasodilation especially in the presence of shock or hypovolaemia.

The necessity of providing adequate fluid loading to patients who are about to receive spinal anaesthesia with local anaesthetics is now recognised as an integral part of anaesthetic management.
"Then let it be said that intravenous anaesthesia is also an ideal method of euthanasia. It was the consensus of all civilian surgeons concerned that, considering all the hazards of patient, anaesthetist and anaesthetic, open drop ether still retains the primacy!"

Halford, F.J. 
A Critique Of Intravenous Anaesthesia In War Surgery  
Anesthesiology, 4, 67-69, 1943

"Intravenous Anesthesia With Pentothal Sodium In The Case Of Gunshot Wound Associated With Accompanying Severe Traumatic Shock And Loss Of Blood: Report Of A Case"

Adams, R.C and Gray H.K. Anesthesiology  
4, 70-73, 1943

Case synopsis  
26-year-old woman suicide  
a 12 bore below and left of the left breast  
"A portion the left side of the thorax had been blown away and compound comminuted fractures of ribs 6, 7, 8 and 9 had been sustained.... The spleen, a portion of stomach and a portion of the left lung were projecting from the wound of exit. There was a large laceration of the diaphragm through which all these intra-abdominal structures also protruded".

on admission • morphine • O₂ • blood  
induced using 25 mg increments (0.5 mg kg⁻¹/min)  
required 2.5 mg kg⁻¹ for induction  
surgery 25 mg increments TFX • lasted 1 h 45 min  
total dose received 400 mg  
recovered in an oxygen tent  
(normal dose 4 – 8 mg kg⁻¹)

"We think this case supports the belief that pentothal sodium may safely be administered intravenously for anaesthesia to patients who are in a state of shock from trauma, provided their low tolerance for this and similar drugs is recognised and administration is conducted accordingly".

Adams, R.C and Gray H.K.
Shock greatly diminishes the effective circulating blood volume, decreases cardiac output, decreases the volume of distribution and increases the plasma concentration of an intravenously administered drug. Small drug doses can have a big effect and for a lot longer time than in a normal patient. The dose of all intravenous anaesthetics is the same: Slowly to effect.

Understanding pathophysiology is fundamental in dealing with an anaesthetic emergency and for administering an anaesthetic in an emergency.

Useful monitors

- Trained staff
- Pulse oximeter (SpO₂)
- Capnograph (ETCO₂)
- Oesophageal stethoscope (HR)
- ECG
- Non-Invasive Blood pressure (mm Hg)
- Agent monitoring (Fi and ET anaesthetic %)
- Manometer in patient breathing system (cm H₂O)
- Thermometer

Anaesthetic emergencies: Learnt and practiced response

- knowledge of appropriate responses to an anaesthetic emergency is essential
- understand why emergencies arise and how they may be prevented
- Learn, modify, change, train, improve

Errors, Incidents and Accidents in Anaesthetic Practice

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SUMMARY

Human errors is a pervasive and normal part of everyday life and is of interest in the anaesthetic because errors may lead to accidents. Definitions of, and the relationships between, errors, incidents and accidents are provided as the basis for this introduction to the psychology of human error in the context of the work of the anaesthetist. Examples are drawn from the Australian Incident Monitoring Study (AIMS). An argument is put forward for the use of nonconfrontational incident reporting including relevant contextual information as well as details of our cognitive processes, rather than the use of accident investigation after the event (with the obvious problems of bias, information, denial, perception and outcome bias). A classification of errors is provided. "Active" errors may be classified into knowledge-based, skill-based, and technical errors. Different analyses are required for the prevention of each type and it may now be safe to place more emphasis in anaesthetic practice on cognitive rather than technical errors. Since the past, "latent" errors make an enormous contribution to problems in anaesthesia and neonatal anaesthesia are discussed (e.g. environment, physiological state, assessment, work places, personnel training, social and cultural factors). An approach is provided for the prevention and management of errors, incidents, and accidents and which allows clinical problems to be quantified, the relative importance of various contributing factors to be established, and appropriate preventative strategies to be devised and implemented on the basis of priorities determined from the AIMS data. Accidents cannot be abolished, however, an understanding of the factors underlying them can lead to the rational direction of resources and effort to prevent them and minimize their effects.
Accidents, errors and incidents

- An incident is an unintended event that potentially could lead to harm and reduces the safety margin.
- An accident is an adverse or negative outcome.
- An error is a flawed plan or action where some aspect of performance deviated from the ideal. It does not imply blame.
- Accidents are often products of unlikely co-incidents, and prevention is difficult.
- Errors are largely systematic, relatively easy to predict and prevent.

Errors

Consider the chain of events:
GOAL ---->
INTENTION ---->
PLAN ---->
ACTION ---->
OUTCOME

Classification of Problems in anaesthesia

- Latent errors (contributing factors)
- Active errors
- Factors minimising adverse events
- Outcomes

Latent error: example

Types of active errors

- Knowledge based
- Rule based
- Skill based (slips and lapses)
- Technical
Types of active errors

- Running out of oxygen during an anaesthetic is a rule based error since there was a failure to follow the plan for “Anaesthetic Machine Check” to be carried out prior to every anaesthetic.

Errors and accidents: example

Systematic error:
Repetitive hypothermia in patients undergoing anaesthesia in winter

Accident:
Ventricular tachycardia, arrest and resuscitation in a 9 year old 3kg dog undergoing bilateral repair of multiple pelvic fractures. Rectal temp noted 31.8°C

Errors and accidents: example

Systematic error:
Repetitive upper airway obstruction in patients anaesthetised for dental procedures because pharyngeal throat-packs had been inadvertently left in situ after extubation

Accident:
Fortunately a cardiac arrest never eventuated, but several dogs passed gauze swabs after 1-2 days

Solution:
1) All dental patients have a pharyngeal placed with a long tie of bright tape attached... Always!
2) All dental patients have their oropharynx examined with a laryngoscope prior to recovery

Errors and accidents: example

Systematic error:
Hypothermia (cont)

Solution:
Warm air blankets in all surgeries and radiant heating lamps over induction tables

Errors and accidents: example

Prevention is Important
But what about..... Disasters!
Human error

80% of serious incidents in complex systems where humans and machines interact involve human error.

Crisis in Practice

- Rapidly evolving complex event
- Tightly coupled situation

• One false move can lead to catastrophe

Tightly coupled and Complex systems are inherently dangerous!

- Charles Perrow “Normal Accidents” 1984
- High complexity in a system means that if something goes wrong it takes time to work out what has happened and to act appropriately.
- Tight coupling means that one doesn’t have that time.
- A tightly coupled system needs centralised management, but a highly complex system can’t be managed effectively in a centralised way because we simply don’t understand it well enough; therefore its organisation must be decentralised.

The Kegworth UK aircraft disaster 1989 – 47 dead

The aircraft was a British Midland 737-400, G-OBME, on a scheduled flight from Heathrow Airport to Belfast, Northern Ireland, flying a route known as Heathrow to Belfast and back. The flight was taking off from Heathrow at 17:59, and the flight plan showed that the aircraft was climbing at 10,000 feet to reach its cruising altitude of 35,000 feet. One of the fan blades on the left engine suddenly ruptured.

While the pilots did not know the source of the problem, a pounding noise was suddenly heard, accompanied by severe vibrations. Smoke poured into the cabin through the ventilation system and a smell of burning entered the plane. Several passengers sitting near the rear of the plane noticed smoke and sparks coming from the left engine.

The flight was diverted to nearby East Midlands Airport at the suggestion of British Midland Airways Operations.

After the initial blade failure, Captain Kevin Hunt had disengaged the plane’s autopilot. When Hunt asked First Officer David McClelland which engine was malfunctioning, McClelland replied: “It’s the left... it’s the right one.” In previous versions of the 737, the air conditioning ran through the right hand engine, but on the 737-400 it ran through both. The pilots had been used to the older version of the aircraft and did not realize that this aircraft (which had only been flown by British Midland for 520 hours over a two-month period) was different. When they smelled the smoke they assumed it was coming from the right engine; this led them to shut down the working right engine instead of the malfunctioning left engine. (They had no way of visually checking the engines from the cockpit, and the cabin crew did not inform them that smoke and flames had been seen from the left engine.)

When the pilots shut down the right engine, they could no longer smell the smoke, which led them to believe that they had correctly dealt with the problem. As it turned out, this was simply a coincidence: when the autothrottle was disengaged to shut down the right engine, the fuel flow to the left engine was reduced and the excess fuel which had been igniting in the jet exhaust disappeared; therefore, the ongoing damage was reduced, the smoke smell ceased, and the vibration reduced, although it would still have been visible on cockpit instruments. The pilots, however, did not consult the vibration detectors because these had been unreliable in previous planes they had flown.

During the final approach to the East Midlands Airport, more fuel was pumped into the damaged engine to maintain speed, which caused it to cease operating entirely and burst into flames. The flight crew attempted to restart the right engine by removing the fuel flow rate, but this had little effect. The engine damage was not evident; the engine was stopped and the vibration reduced, although it would still have been visible on cockpit instruments. The pilots, however, did not consult the vibration detectors because these had been unreliable in previous planes they had flown.

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Acknowledgements: At the 2009 Darwin National AVA conference, Dr Colin Dunlop presented this example in a talk on “Normal Accidents” in aviation. The incident was reported by the UK Air Accidents Investigation Branch in March 1990 and also featured in Perrow’s book “Normal Accidents.”
An accident survey of 1,843 aircraft accidents from 1950 through 2006 determined the causes to be as follows:

- 53%: Pilot error
- 21%: Mechanical failure
- 15%: Weather
- 8%: Other human error (air traffic controller error, improper loading of aircraft, improper maintenance, fuel contamination, language miscommunication etc.)
- 6%: Sabotage (bombs, hijackings, shoot-downs)
- 1%: Other cause

Recovery from failure

"Tightly coupled systems can survive failures, provided that the failure has been anticipated and provided for" Perrow 1984

but....(to err is human)

- The operators must avoid taking actions whose consequences have not been analysed
- The operators must respond correctly to all incidents and failures

Human error

- Flight 1549 was a scheduled commercial passenger flight from New York City to Charlotte, North Carolina, that, on January 15, 2009, ditched in the Hudson River adjacent to Manhattan six minutes after departing from LaGuardia Airport.
- While on its initial climb out, the Airbus A320 struck a flock of Canada Geese which resulted in an immediate almost complete loss of thrust from both engines. When the aircrew determined that the aircraft would be unable to safely reach any airfield from its location just northeast of the George Washington Bridge, they turned it southbound and glided over the river into which they successfully ditched the airliner near the USS Intrepid museum in midtown Manhattan about three minutes later. All 155 occupants safely evacuated the still virtually intact (although partially submerged and slowly sinking) airliner from which they were quickly rescued by nearby watercraft.
- The entire crew of Flight 1549 was later awarded the Master's Medal of the Guild of Air Pilots and Air Navigators. The award citation read, "This emergency ditching and evacuation, with the loss of no lives, is a heroic and unique aviation achievement." Source: Wikipedia

Anaesthetic emergencies

- Rapidly evolving series of cascading events usually of increasing complexity
- Often exceeds ability of one person to process all aspects of the situation
- Tightly coupled situations: One false move can lead to catastrophe

Classification of emergencies

Stephen Covey ‘The Seven Habits of Highly Effective People’

Quadrant 3
- e.g. The pulse oximeter probe is disconnected

Quadrant 1
- e.g. No pulse

Quadrant 4
- e.g. The Vet’s speeding fine this morning

Quadrant 2
- e.g. Low oxygen, but reserve cylinder is full

Urgency

Importance
Dealing with Crises

- Gut feeling, Intuition
- First principles

Intuition

- A $10 banknote folded in half, then half again, repeated a total of 100 times
- How thick would it be?

Approximately the same as the width of the known universe:

43 billion light years

Intuition without knowledge is extraordinarily dangerous

Dealing with Crises

- First principles
  vs
- Learned and practiced algorithms and standardised procedures
  e.g. ABCD algorithm for cardiopulmonary resuscitation (CPR)

Is a “basic principles” approach suitable in an emergency situation?

- An exercise in first principles:
  - First principles:
    - Everyone reading this knows the alphabet
    - Everyone knows the months of the year….
  - Emergency situation:
    - Declare an emergency in which you have 2 minutes to deliver the correct answer without use of pen, paper or electronic device
  - Emergency problem:
    - Next slide….

Emergency !!!

- What are the months of the year in alphabetical order?

Is a “basic principles” approach suitable in an emergency situation?
Conclusion:

- In an emergency, relying on first principles or intuition without knowledge are likely to produce a poor outcome
- Best choice in an emergency is to utilise learned and practiced algorithms and/or standardised procedure response

Undesirable responses in crises

- Chaotic and noisy
- Superficially and calm but ineffective

Inappropriate thinking strategies

- Frequency gambling
- Coning of attention
- Confirmation bias or mindset

Declaring an Emergency

- Early recognition
- Prompt declaration
- Call for assistance
- Allocate tasks

Minimising errors and accidents

Adopt standardised protocols:

- Cleaning and maintenance
- Checking anaesthetic machine
- Preparation for patient anaesthesia
- Anaesthetic record
- Protocol for anaesthetic emergencies

Algorithm for Problems during Anaesthesia

- For anaesthetised spontaneous ventilating patient:
  - AB COVER CD A SWIFT CHECK

- For anaesthetised mechanically ventilated patient:
  - COVER ABCD A SWIFT CHECK
**AB COVER CD A Swift Check**

- A Airway
- B Breathing
- C Circulation & Colour
- D Drugs
- E Endotracheal tube, eliminate machine
- O Oxygen supply, Oxygen analyser
- V Ventilation, Vapouriser
- R Review monitors and equipment

**SWIFT CHECK**

- A be Aware of Air (embolism, pneumothorax), Allergy and Anaphlaxis
- Of patient, surgeon, process, response and environment

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**Effective implementation**

The AB COVER CD A Swift Check mnemonic should be encouraged as the basic check list every person monitoring an anaesthetic employs throughout the period of anaesthesia and recovery!

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**Examples: Hypoxia**

**Response:**

**Recognition:**
- 

<table>
<thead>
<tr>
<th>SpO2&lt; 90%, PaO2 &lt; 60mmHg</th>
</tr>
</thead>
</table>
- Cyanosis, Tachycardia, increased respiratory effort initially
Causes: Hypoxic gas mix, Poor perfusion, lack of ventilation, poor gas exchange, anaemia

**Treatment:**
- Eliminate machine causes
- Follow the surgeon line from high pressure gas line, anaesthetic machine, common gas outlet port, correct patient breathing system, connected to ET tube, correctly placed ET tube, exhaust valve, scavanger
- Improve cardiac output
- Decrease depth of anaesthesia
- IV fluid bolus
- Positive inotrophes if needed
- Improve alveolar ventilation
- Gently assisted or artificial ventilation (note decreases cardiac output)
- Improve tissue oxygenation
- Increase inspired oxygen concentration (95%)
- Transfuse in PCV < 20%
- Increase cardiac output

**Examples: Hypotension**

**Response:**

**Recognition:**

<table>
<thead>
<tr>
<th>Mean arterial blood pressure&lt; 60mmHg, systolic arterial pressure &lt; 80mmHg</th>
</tr>
</thead>
</table>
- Poor or undetectable pulse
- Pale or muddy mucous membranes (old peripheral vasoconstriction)
Causes: Excessive anaesthetic depth, blood loss, dehydration, vasodilation, poor venous return to the heart (what is the surgeon doing?)

**Treatment:**
- Check no Hypoxia
- Decrease anaesthetic depth
- Improve cardiac output
  - Decrease depth of anaesthesia
  - IV fluid bolus 10ml/kg rapidly
  - Positive inotrophes if needed
- Maintain tissue oxygenation
  - Maintain PCV > 20% and TPP > 35gm/L
Examples: Hypoventilation

Response: AB COVER CD A SWIFT CHECK.

Recognition:
- Reduced rate and or tidal volume.
- Difficulty maintaining anaesthesia
- Increased HR and BP
- Elevated ET CO2

Causes:
- Excessive depth of anaesthesia
- Inability to expand the chest
- Airway obstruction

Treatment:
- Check you are administering oxygen (Hypoventilation always causes hypoxia unless O2 enriched inspired gas mixture is administered)
- Compress the rebreathing bag and deliver a positive pressure breath: inflate the chest check there is no airway obstruction, or disconnect.
- Apnoea on induction: Manually ventilate 2-4x per minute, not to often or the PaCO2 will fall and the apnoeic threshold exceeded
- Reduce anaesthetic depth
- Reposition ET tube or patient
- IPPV

Thank you!
Smokey & Kato