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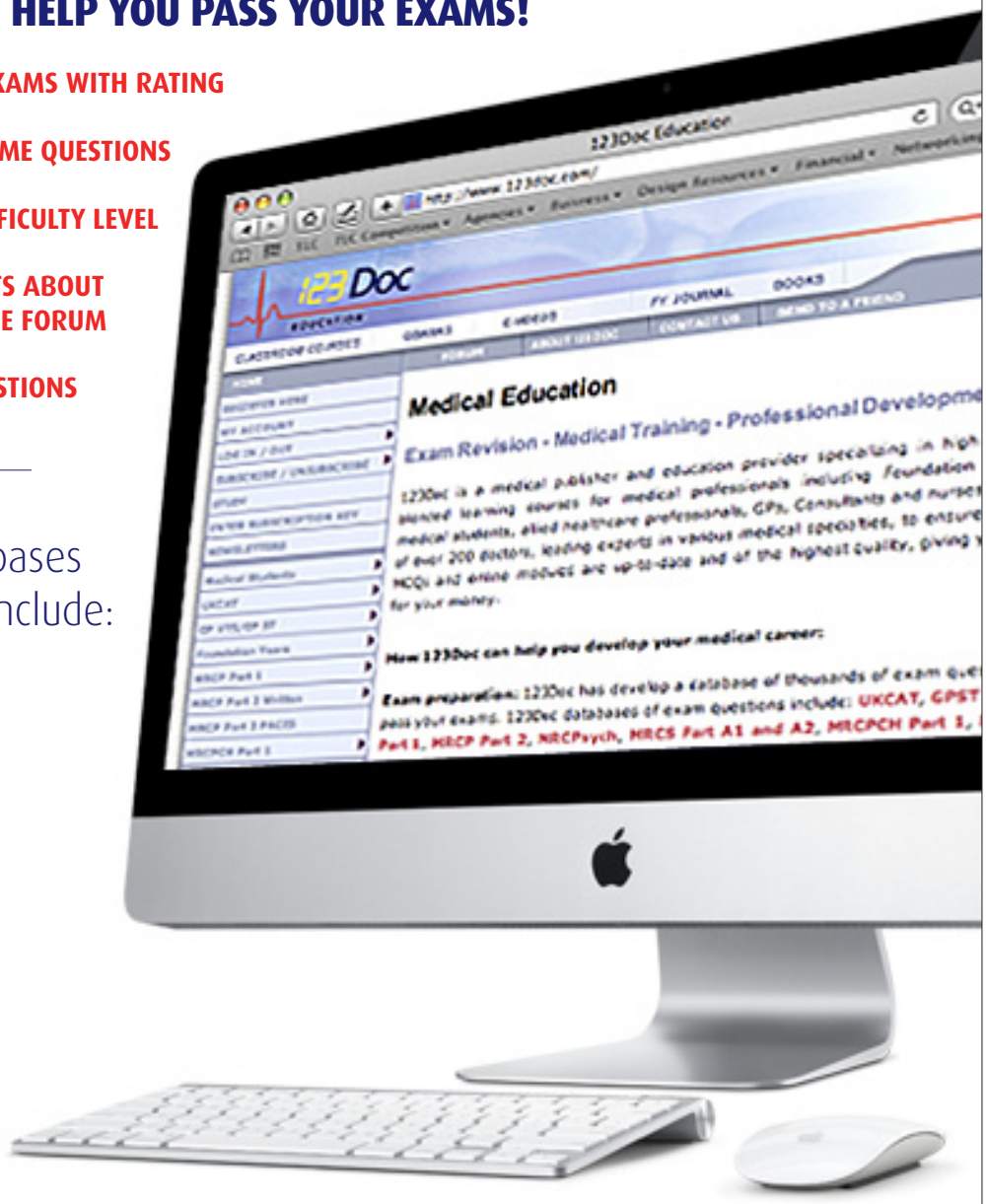

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FOUNDATION YEARS JOURNAL 2015

Volume 9

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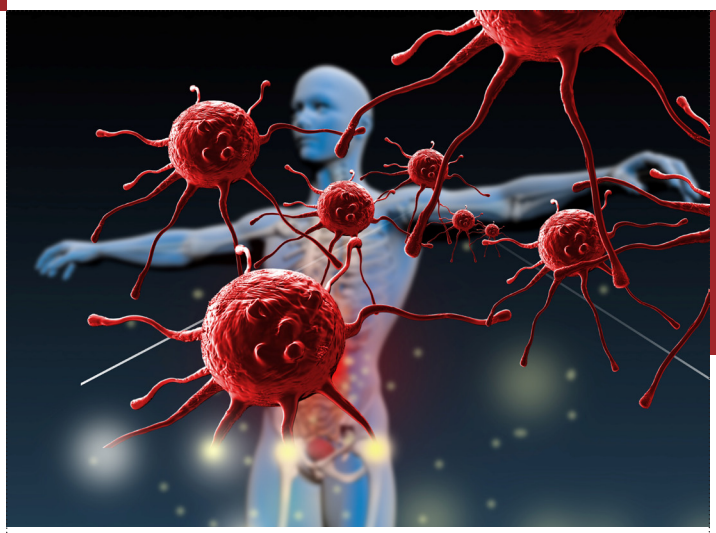
A CASE OF REDUCED GCS IN AN IMMUNOCOMPRIMISED PATIENT

L Gemmell, A Gemmell & V Cunningham



Abstract

The ability to recognise the acutely ill patient is a skill that all foundation doctors should have and guidelines from NICE and surviving sepsis prompt this. Severe sepsis is a major cause of morbidity and mortality, with an annual mortality rate of 35% (1). The surviving sepsis guidelines implementation in hospital has been shown to reduce mortality, decrease length of stay and reduce intensive care bed days. (2,3)

The prompt assessment, institution of appropriate investigations and management and involvement of senior doctors has been shown to reduce mortality in this patient group. Sepsis Six is the name given to the bundle of medical therapies designed to reduce the mortality of patients with sepsis. These simple measure can save lives. All foundation doctors who will work in an acute receiving unit should possess these skills.

Source control is fundamental to the treatment of sepsis and vital for overall morbidity and mortality. We present a rare case of reduced GCS in an immunocomprimised patient. Invasive fungal infections are rare, but should be considered in patients who are immunocomprimised, those with solid organ transplants taking immunosuppressants and those with haematological malignancies.

Summary

A 59 year old female, with a history of Crohn's disease and immunosuppression, requires an urgent laparotomy for generalised peritonitis. Post-operative care in Intensive Care is stormy, requiring multi-organ support. Clinical improvement allowed an attempt at extubation. Unfortunately, further deterioration - this time in her neurological condition, prompted further investigation. The key feature of this case is prompt assessment of the acutely ill patient, with the institution of appropriate investigations and management. Consideration of source control in the septic patient is vital for overall morbidity and mortality.

A Case Of Reduced GCS In An Immunocomprimised Patient
Patient Management

Case Report

A 59 year old female with long standing Crohn's disease was admitted with small bowel obstruction to the surgical unit. She had a known terminal ileal stricture for which she had previously refused surgery. Her Crohn's disease was medically managed with immunosuppressants and steroids. She had undergone no prior surgical interventions.

On admission to hospital, she was severely malnourished: admission weight was 35kg; admission albumin was 11g/dL. Routine bloods showed a marked neutropenia and raised inflammatory markers. She was treated with intravenous steroids and empirical antibiotics. The patient proceeded to theatre to undergo a laparotomy, which revealed both ischaemic bowel and small bowel perforation. She was subsequently transferred to the Intensive Care Unit for further management.

Post-operatively the patient's care was turbulent, with developments of: acute respiratory failure; acute kidney injury; and acute bone marrow suppression as sequelae of severe sepsis. These required: prolonged ventilatory support; renal replacement therapy; and platelet/red cell transfusions. Prophylactic antibiotic therapies for upper gastrointestinal perforation were stopped after 14 days due to signs of clinical improvement. Her neurological examination was unremarkable at this time following cessation of sedation. She then had a trial of extubation which failed, and subsequently had a percutaneous tracheostomy placed.

Over the course of the following week, the patient had a further deterioration in her clinical condition. Her temperature was raised at 38.8°C; respiratory rate was raised at 40 breaths/minute; and heart rate was raised at 125bpm and irregular. Blood pressure at this point was normal; examinations of her chest and abdomen were unremarkable; and neurological examination remained unchanged. Blood results revealed a marked neutrophilia with raised inflammatory markers; blood cultures were negative for growth after 5 days' incubation; serum lactate was raised at 3mmol/L. Sepsis was therefore considered the most likely cause of her condition, although the source was unclear – empirical intravenous antibiotic therapy was restarted.

The next day, her GCS had suffered a rapid deterioration with localising signs – antibiotic therapy was escalated at this point. She continued to show signs of SIRS but now remained hypotensive with a blood pressure of 80/40, despite adequate fluid resuscitation. Biochemistry results revealed an acute kidney injury, and a diagnosis was made of septic shock.

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What investigations are required next?

Due to the sudden deterioration in her GCS, a CT scan of her head was organised – this revealed frontal haemorrhages and ring enhancing lesions in the cerebellum with surrounding oedema. The appearances were consistent with multifocal sites of infection.

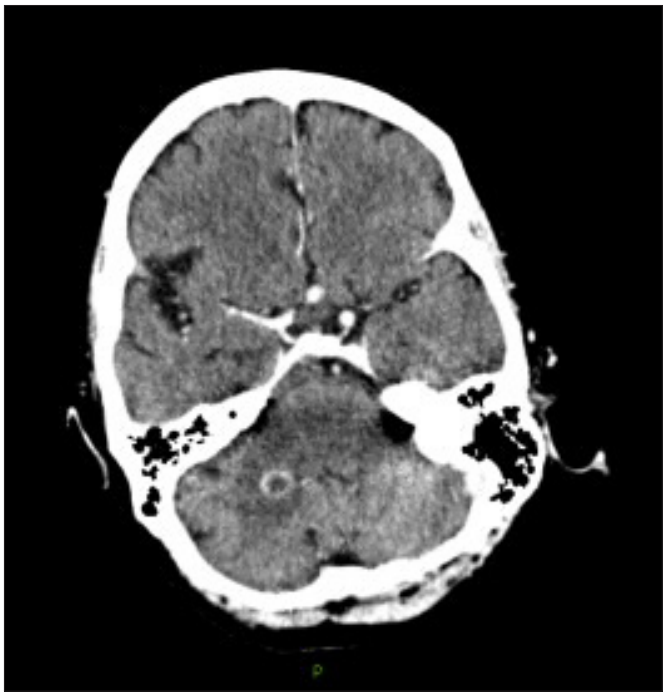

Figure 1: A case of reduced GCS in an immunocomprimised patient.

Following this, a lumbar puncture was performed. The results showed: an opening pressure of >40mmHg; WCC >400/mm^3 (predominantly polymorphs); red cell count 28/mm^3; glucose 3.0 (serum glucose 4.4); and protein 0.53. There was no bacterial growth from the CSF culture.

What is the differential diagnosis?

The following differential diagnoses were considered:

1. *Cerebral abscess*
2. *Tuberculoma*
3. *Metastases*
4. *Demyelinating disease*
5. *Lymphoma*
6. *Toxoplasmosis*
7. *Varicella Zoster*
8. *Invasive fungal infection*

What happened next?

Following discussion with neurosurgery, it was felt that due to the poor physiological state of the patient and the multi-focal sites of infection making the patient less amenable to neurosurgical intervention she continued with her current treatment and source control was not an option.

Further information became available from microbiology cultures: CSF tested strongly for aspergillus, whilst blood borne viral screen returned negative.

Over the next 24 hours, despite full active treatment with antibiotics and antifungals, her GCS continued to fall and her pupils became fixed and dilated. Active treatment was withdrawn and supportive care only was adopted. She died peacefully the following day.

Discussion

Key features of this case include: the assessment and prioritisation of the acutely ill patient in hospital; initial management; recognition of sepsis; and implementation of the surviving sepsis guidelines. Severe sepsis is a major cause of morbidity and mortality. The surviving sepsis guidelines were published in 2004, and recently updated in 2012 (2). Increasing compliance with the use of bundles of care in the surviving sepsis guidelines showed an absolute mortality reduction of 5.4% over 2 years (3).

1. Assessment of the acutely ill patient

The foundation doctor is extremely likely to be called as first responder to an acutely ill patient. Although the case above describes a patient in an intensive care environment, the principles of assessment and treatment remain the same for doctors of all levels of experience and training. Using a systematic approach based on resuscitation council guidance: A (Airway), B (Breathing), C (Circulation), D (disability), E (exposure) are the vital components to the assessment of any patient in which we are called to see (4).

The key principles from the resuscitation council are:

1. Undertake a complete initial assessment and re-assess regularly
2. Always assess the effects of treatment or other interventions
3. Always correct life threatening abnormalities
before moving on to the next part of assessment
4. The assessment of the acutely ill patient is often
multi-disciplinary, with senior help required at an early stage

NICE also published guidance and management of the acutely ill patient in hospital (5). This compounded the evidence from the resuscitation council and established the use of the physiological observation chart to alert nursing and medical staff to the potentially deteriorating patient.

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A (Airway)

All acutely ill patients should receive high flow oxygen. Ask the patient simple questions as a response ensures a patent airway. Look for signs of airway obstruction – use of accessory muscles, cyanosis, inspiratory or expiratory stridor. Acute airway obstruction is a medical emergency and requires the assistance of an anaesthetist promptly.

B (Breathing)

During the immediate assessment of the respiratory system, any positive findings should be treated immediately. Monitor the respiratory rate, as tachypnoea is an independent predictor of deterioration. Look for signs of respiratory distress: sweating, cyanosis, and use of accessory breathing muscles. Take oxygen saturations using a pulse oximeter. Palpate, percuss and auscultate the chest, listening for breathing sounds. Bronchial breathing indicates lung consolidation whereas absent or reduced sounds suggests a pneumothorax or pleural fluid. Consider investigations such as arterial blood gases or a chest x-ray.

C (Circulation)

Assess limb temperature – this single test can tell a doctor a great deal about the patient's circulatory state. Take the patient's heart rate and blood pressure, and check central capillary refill time. Obtain intravenous access – large bore is preferable as this will allow the highest flow rate. Take bloods for routine biochemical and haematological investigations. Look for causes of accompanying hypotension if present – treat with intravenous fluids and assess response (consider urinary catheter). Re-assess heart rate and blood pressure regularly to assess response to interventions. If refractory hypotension remains despite treatment, seek senior help and advice.

D (Disability)

Assess conscious level using the AVPU or GCS score – a GCS of less than 8 signifies a lack of airway patency and experienced help should be sought. Monitor blood glucose levels for any hypoglycaemia, and check medication charts for possible causes of reduced conscious level.

E (Exposure)

Examine all systems and carry out a secondary survey to ensure that no clinical signs have been missed. Review the need for laboratory and radiological investigations. Consider which level of care is required for the patient and involve appropriate senior or specialist help.

2. Implementation of the surviving sepsis guidelines

Although as foundation doctors, you would not be expected to independently manage a patient with severe sepsis or septic shock, you would be expected to be able to assess the acutely ill patient and be able to formulate an appropriate initial management plan(s). For a patient with severe sepsis, the ability to do this well could change their hospital outcome (2, 3).

Sepsis is defined as the presence (probable or documented) of infection, together with systemic manifestations of infection. Severe sepsis is defined as sepsis plus sepsis-induced organ dysfunction or tissue hypoperfusion. Septic shock is defined as sepsis-induced hypotension persisting despite adequate fluid resuscitation. Sepsis induced tissue hypoperfusion is defined as infection-induced hypotension, elevated lactate or oliguria (5).

SIRS criteria
(> 2 meets SIRS definition)
-Temp >38°C or <36°C
- Heart Rate > 90bpm
- Respiratory rate > 20 breaths/minute
- WCC >12 or <4mm^3

Sepsis
(SIRS + source of infection)

Severe Sepsis
(Organ Dysfunction, Hypotension or Hypoperfusion)
- Lactic acidosis,
- Blood pressure <90mmHg

Septic Shock
- Severe Sepsis with hypotension despite adequate fluid resuscitation

Figure 2

What do we expect you to do?

The Sepsis Six Bundle

This is the name given to the bundle of medical therapies designed to reduce the mortality of patients with sepsis. It was developed in 2006 as an educational programme to raise awareness and improve the treatment of patients with sepsis (6). In the surviving sepsis guideline, it has been shown that early implementation of treatment (within the 1st hour) has been shown to reduce mortality, decrease length of stay and reduce intensive care bed days (2,3).

The bundle consists of 3 diagnostic and 3 therapeutic steps. These are:

1. Deliver high flow oxygen
2. Take blood cultures and consider source control – i.e. where do you think the source of sepsis is?
3. Administer empirical broad spectrum intravenous antibiotics
4. Measure serum lactate and full blood count
5. Start intravenous fluid resuscitation (30ml/kg crystalloid)
6. Commence accurate urine output – consider urinary catheter

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These simple measures can save lives. The timely implementation of treatment and the recognition of the acutely ill patient with involvement of senior help can save lives. All foundation doctors who will work in an acute receiving unit should possess these skills.

3. Fungal infections in immunocompromised patients

The case described above is rare, however you will be asked to see many patients as a foundation doctor who present with a reduced GCS. The assessment of such patients is described above. However, as described in the surviving sepsis guidelines, source control and the administration of appropriate antibiotics in a timely manner are key to the management of these patients. Invasive fungal infections are on the increase, with an increased prevalence in the critical care setting. (7)

Fungal disease is most commonly seen in the severely immunocompromised patient, those with solid organ transplants taking immunosuppressants and those with haematological malignancies (8). As foundation doctors, when considering starting antibiotics, think about the potential source of infection and start antibiotics or indeed anti-fungals appropriate for the suspected site of infection.

Fungal infections are difficult to diagnose and treat – maintain a high degree of suspicion if called to see a patient who may be more at risk of developing such an infection and involve senior help following your immediate assessment.

Multiple choice questions

1. The Systemic Inflammatory Response syndrome (SIRS): Which of the following would suggest the patient had sepsis?

a.) BP 124/81, HR 85, Temp 36.8, RR 18, positive urine culture
b.) BP 102/51, HR 120, Temp 37.1, RR 16, no positive cultures
c.) BP 140/80, HR 108, Temp 36.5, RR 12, no positive cultures
d.) BP 110/50, HR 125, Temp 37.5, RR 30, cellulitis right leg
e.) BP 110/60, HR 110, Temp 36.1, RR 13, no positive cultures

2. Fungal infections: Which anti-fungal should be prescribed to treat aspergillus infection?

a.) Fluconazole
b.) Amphotericin B
c.) Itraconazole
d.) Voriconazole
e.) Caspofungin

3. Sepsis: Group A streptococcal sepsis has a high mortality. How might these patients present?

a.) Impetigo
b.) Pneumonia
c.) Sore throat
d.) Necrotising fasciitis
e.) All of the above

4. Lactate: A raised serum lactate is indicative of tissue hypoperfusion. Which of these would NOT cause a lactic acidosis:

a.) Hypoxia
b.) Massive blood transfusion
c.) Sepsis
d.) Poor diabetic control
e.) Rhabdomyolsis

5. Assessment of the acutely ill patient: A GCS score of less than 8 suggests airway patency may be in doubt. Which of these scenarios would cause concern over airway patency?

a.) Eyes open spontaneously; confused; localising to pain
b.) Eyes open to pain; confused; flexing to pain
c.) Eyes not opening; incomprehensible sounds; withdrawal to pain
d.) Eyes opening to voice; inappropriate words; localising to pain
e.) Eyes open spontaneously; confused; obeying commands

MCQ Answers

1. Answer D

The diagnosis of sepsis is the presence of 2 or more features of the Systemic Inflammatory Response Syndrome with a suspected or present source of infection. Option D is the only observations that meet these criteria. Option B has evidence of SIRS but not of sepsis with cultures being negative. However, if there was suspicion of infection, this would qualify as sepsis.

2. Answer D

The infectious Diseases Society of America (IDSA) released guidelines for the treatment of invasive aspergillus. The guidelines recommend monotherapy with voriconazole for initial therapy of invasive aspergillosis. If there is no response to monotherapy with voriconazole, guidelines suggest adding caspofungin as an additional agent (9,10).

3. Answer E

Few people who come into contact with Group A streptococcus will develop invasive disease. Most people will have a simple infection such as a sore throat or impetigo, some may only be colonised with no symptoms at all. Healthy people can develop invasive group A streptococcal disease but it is more common in patients with chronic co-morbidities, the immunosuppressed and pregnant mothers are at higher risk.

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4. Answer B

Metabolic acidosis is due to the inadequate clearance of acid from the blood. Lactate is the by-product of anaerobic respiration, which is normally cleared by the kidneys, liver and skeletal muscle. An acidosis occurs usually in state of tissue hypoperfusion and/or hypoxia.

A massive blood transfusion causes a metabolic alkalosis. Massive blood transfusions (replacement of a patient's total blood volume in <24hours) can cause a metabolic alkalosis due to red blood cells containing 102mmol of acid, which is generated from the citric acid of the anticoagulant and the lactic acid produced during storage. Citrate undergoes hepatic metabolism to bicarbonate during a massive transfusion, and a metabolic alkalosis can occur (11).

5. Answer C

Glasgow Coma Scale (GCS) provides a practical assessment for impairment of conscious level in response to defined stimuli.

Eye Opening	*Spontaneous*	*4*
	To sound	*3*
	To pain	*2*
	None	*1*
Verbal Response	*Orientated*	*5*
	Confused	*4*
	Inappropriate words	*3*
	Incomprehensible sounds	*2*
	None	*1*
Motor Response	*Obeys commands*	*6*
	Localising pain	*5*
	Withdraws from pain	*4*
	Abnormal flexion	*3*
	Abnormal extension	*2*
	No response	*1*

A GCS of less than 8 indicates that airway patency may be in doubt. This may require the expertise of anaesthetists to secure the airway.

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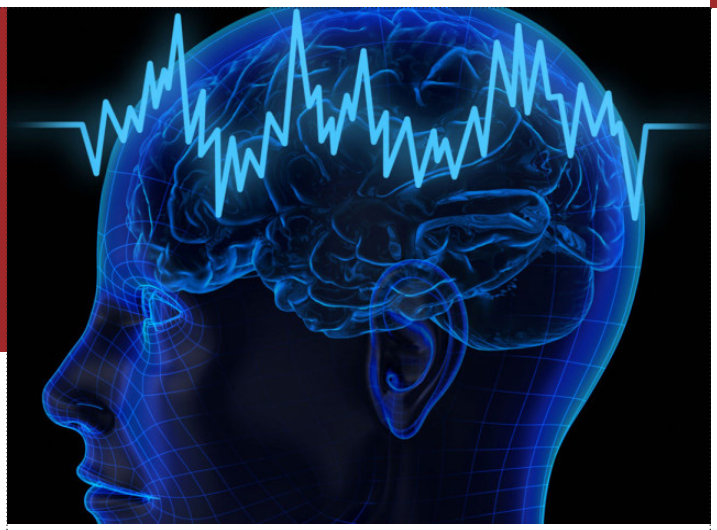
A CASE OF SUXAMETHONIUM APNOEA DURING ELECTROCONVULSIVE THERAPY

P Tizzoni, J Hillier

A Case Of Suxamethonium Apnoea During Electroconvulsive Therapy
Patient Management



Abstract

This article describes a case of suxamethonium apnoea during ECT, highlighting this rare, but important adverse effect. It discusses how it is recognised, the immediate management and subsequent investigations, as well as discussing the risks of anaesthesia in remote areas.

Introduction

First described in 1938, electroconvulsive therapy (ECT) is the oldest existing physical treatment in psychiatry. For many years, it was performed without anaesthetic. Nowadays, a general anaesthetic is used for patient safety and comfort. Numerous anaesthetic agents are available, however, suxamethonium remains the most commonly used muscle relaxant (1,2,3).

Case History

A 69 year old lady undergoes ECT treatment for resistant depression. She has no significant medical history and takes venlafaxine, mirtazapine, olanzapine and lithium. After checking consent and fasting status, full monitoring is applied. She is cannulated, pre-oxygenated and anaesthesia is induced with methohexitone, before administering suxamethonium. A bite block is inserted and she has bilateral ECT, provoking a visible tonic-clonic seizure of 38 seconds and 59 seconds of electroencephalogram (EEG) changes.

Her airway is supported while waiting for spontaneous respiration. After two minutes, there is still no respiratory effort. Meanwhile, her heart rate and blood pressure start to rise – it appears she is regaining consciousness while still paralysed from the suxamethonium. Further doses of methohexitone are given to maintain anaesthesia while waiting for the suxamethonium to be metabolised. Sixteen minutes later she regains full muscle strength and spontaneous ventilation and is taken to the recovery room.

Discussion

In total, this lady was paralysed for approximately 20 minutes – 3 to 4 times the usual duration. It can therefore be classified as a mild form of suxamethonium apnoea(4,5).

Although this is not directly life-threatening (in the presence of an anaesthetist), patients with suxamethonium apnoea require maintenance of anaesthesia and appropriate airway support until neuromuscular function has returned(4,5). In the usual anaesthetic theatre environment, close to a well-staffed recovery room and intensive care department, appropriate measures can be organised promptly(6,7).

ECT treatment however, is usually administered in mental health hospitals, detached from the main hospital grounds and remote from the usual anaesthetic environment. Emergencies often require dialling 999 to transfer the patient to the closest hospital, while initiating advanced life support measures, led by the anaesthetist(6,7).

In order to minimise preventable risks, the Royal College of Anaesthetists has guidance on the provision of anaesthesia in remote areas. These include(6,7):

- *Provision or supervision of anaesthesia by a named, experienced consultant*
- *Presence of an experienced and dedicated anaesthetic assistant*
- *Standardisation of equipment where possible or regular opportunities for full familiarisation with different equipment*
- *Monitoring equipment complying with national standards*
- *Appropriate area and staffing for post-anaesthetic recovery*
- *Emergency bag, including equipment to manage a difficult airway*

A CASE OF SUXAMETHONIUM APNOEA DURING ELECTROCONVULSIVE THERAPY

P Tizzoni, J Hillier

Figure 1: ECT treatment room.

Muscle relaxants in ECT

Prior to the use of muscle relaxants in ECT, limb fractures and dislocations were common. The optimal agent has a short duration of action and prevents injuries by reducing muscle contractions. However, complete muscle paralysis is not necessary for ECT as minimal muscular contractions are useful to monitor seizure duration in addition to EEG monitoring(1,3).

In view of its short duration of action, suxamethonium is the most commonly used neuromuscular blocking agent (NMBA). Due to its numerous adverse effects however, short-acting non-depolarising NMBAs, such as rocuronium, are increasingly trialled. Rocuronium has a similar duration of action, a better side-effect profile and, if required, can be reversed with sugammadex.

Precurarization of suxamethonium with non-depolarizing NMBAs to reduce muscle fasciculation and post-operative myalgia is possible, however the evidence for this in ECT is poor (and the use of a priming dose will prolong the required time for anaesthesia). Longer acting NMBAs may also be used but usually require pharmacological reversal before emergence from anaesthesia. Table 2 gives of brief overview of duration and disadvantages of each(1,2,3).

	Dose (mg/kg)	Time of onset (seconds)	Duration (minutes)	Disadvantages
Suxamethonium	0.5 – 1	30-60	5-10	Hyperkalaemia Bradycardia Malignant hyperthermia
Mivacurium	0.12 – 0.2	120-180	15-20	Histamine release Hypotension
Atracarium	0.3 – 0.5	120-180	20-35	Prolonged duration
Rocuronium	0.3	90	7-13	Efficiency unclear

Table 1: Muscle relaxants for ECT(1,3)

Suxamethonium

Suxamethonium is a depolarising NMBA. It produces a rapid onset of profound neuromuscular blockade and is mainly used for rapid sequence induction, ECT and short duration anaesthesia(3,5).

Its chemical structure is similar to acetylcholine, allowing it to bind to post-synaptic acetylcholine receptors and causing rapid depolarisation of skeletal muscle cells. Initially, this leads to fasciculation. As the suxamethonium remains bound to the receptors, it causes a continuous depolarisation to a membrane potential at which no further action potentials can be triggered. This leads to muscle relaxation and prevents further muscle contractions, hence reducing visible seizure activity(4,5).

Adverse effects(5)

- Bradycardia
- Hyperkalaemia (increased risk in patients with recent burns, paraplegia or muscle trauma)
- Raised intracranial pressure
- Prolonged paralysis
- Malignant hyperthermia
- Muscle aches
- Anaphylaxis

Contraindications(5)

- Hyperkalaemia
- Recent burns (unless <24 hours from injury)
- Paraplegia from spinal cord trauma (avoid days 10-100 post injury)
- Severe muscle trauma
- History of malignant hyperthermia
- Cautious use in patients with known atypical plasma cholinesterase

Suxamethonium apnoea

Suxamethonium metabolism is achieved by the enzyme plasma cholinesterase. Complete metabolism, and hence termination of paralysis, is usually achieved within 5 to 10 minutes of intravenous drug administration. However, plasma cholinesterase action can be reduced or altered in certain patients, leading to a slower breakdown of suxamethonium and therefore much longer lasting paralysis(4,5,9).

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This is a rare condition with varying degrees of severity. It can be inherited or acquired. Table 3 outlines the different causes(4,5,9).

The non-depolarising NMBA mivacurium is also metabolised by cholinesterase and, although it is more easily reversed, should be avoided in reduced cholinesterase activity(4,9).

Inherited	Acquired
Inheritance of plasma cholinesterase is autosomal. The normal gene is $E1^u$. - Commonest mutation: $E1^a$ (4% of caucasians) - Heterozygous inheritance ($E1^uE1^a$): prolonged recovery time of approximately 30 minutes - Homozygous inheritance ($E1^aE1^a$): reduced enzyme function and paralysis for 2 hours or more - Other variations: $E1^f$, $E1^s$ (>3 hours)	Normal enzyme structure but reduced activity (by minutes rather than hours). Causes include: - Pregnancy - Hypothyroidism - Liver disease - Renal disease - Carcinomatosis - Anticholinesterases - Monoamine Oxidase Inhibitors - Methotrexate

Table 3: Aetiology of suxamethonium apnoea(4,5,9)

How to recognise suxamethonium apnoea

If suxamethonium apnoea is not recognised promptly and the induction agent wears off, it will lead to patient awareness while still paralyzed; and if ventilation is not appropriately supported the patient will become hypoxic and hypercapnic. A short duration of awareness is not uncommon and will need to be explained to the patient after recovery(4,5,9).

Unfortunately, the signs of reduced plasma cholinesterase only become apparent at the end of anaesthesia. Neuromuscular monitoring is less useful for suxamethonium than with the non-depolarising muscle relaxants as with the Train-of-four pattern of stimulation usually used in clinical practice fade is not seen. The main clinical indicators are failure to make respiratory effort and lack of response to painful stimuli. Patient awareness can be recognised by their haemodynamic response – hypertension and tachycardia(4,5,9).

Management

Due to the irreversibility of suxamethonium, affected patients require prolonged anaesthesia and ventilation, while waiting for suxamethonium to be metabolised by other, slower mechanisms. Endotracheal intubation and transfer to the intensive care department for ventilation are often required. In severe cases, ventilation is required for up to 7 hours. This leads to numerous risks and complications associated with intubation and ventilation. The primary concern, particularly in remote areas, is failure to intubate a difficult airway (in such cases, the usual protocol for difficult airways should be initiated)(4,5,9).

Investigations

After an episode of suxamethonium apnoea, the patient and their direct family should be offered a blood test to measure the plasma cholinesterase level and confirm the aetiology(9,10).

Initially, the total activity of cholinesterase is calculated by measuring the plasma level of the enzyme butyrylcholinesterase. If this is reduced, it suggests an atypical enzyme variant(9,10).

Subsequently, phenotype studies can be carried out to determine whether the enzyme structure is normal or atypical and provide more information regarding the severity of potential risks to the patient and their family.

Finally, genetic studies should be considered if the phenotype is difficult to identify or a high risk, inherited variant is suspected(9,10).

Conclusion

Suxamethonium is the most commonly used muscle relaxant in ECT and this article described a case of suxamethonium apnoea during ECT. This rare condition is due to a reduced activity of plasma cholinesterase that can be inherited or acquired and varies in severity. It requires maintenance of anaesthesia and appropriate airway support (frequently including intubation and ventilation) until full neuromuscular function has returned. Although appropriate measures can be organized promptly in the usual anaesthetic environment, this case highlights the difficulties of anaesthesia in remote areas, especially when unforeseen complications arise.

Multiple Choice Questions

1) Why is Suxamethonium the preferred muscle relaxant in ECT?

A: Reversibility

B: Short duration of action

C: Low side effect profile

D: Long duration of action

2) Suxamethonium is usually metabolized within...

A: 5 minutes

B: 5-10 minutes

C: 10-15 minutes

D: 15-20 minutes

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3) Which of the following drugs is also metabolised by plasma cholinesterase?

A: Rocuronium

B: Atracarium

C: Mivacurium

D: Methohexitone

4) Which is the commonest gene variation in inherited suxamethonium apnoea?

A: E1f

B: E1u

C: E1s

D: E1a

5) Which investigation should be carried out first after an episode of suxamethonium apnoea?

A: Plasma butyrylcholinesterase level

B: Plasma acetylcholinesterase level

C: Genetic studies

D: Phenotype studies

Answers

1) B **2) B** **3) C** **4) D** **5) A**

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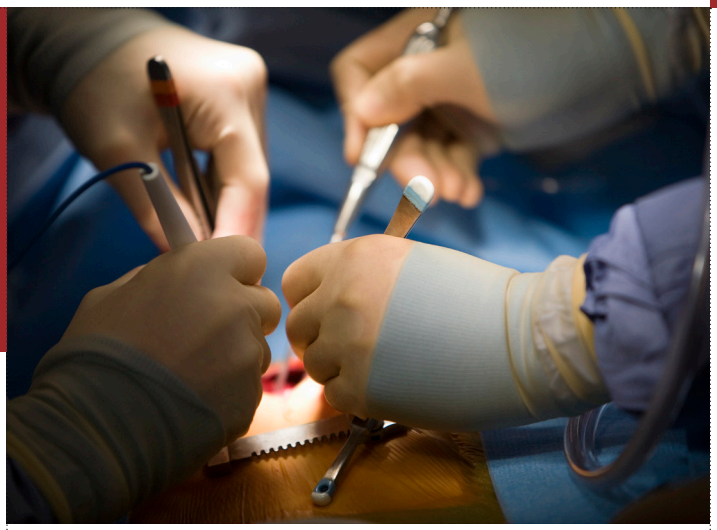
CHRONIC PAIN IN THE ACUTE ELECTIVE SURGICAL SETTING

K Dolphin, J Mendham

Chronic Pain In The Acute Elective Surgical Setting
Patient Management



Abstract

This summary covers the pathophysiology of pain alongside analgesic approaches to management of acute pain in patients with chronic pain as a case study. It will take you through a case from pre-operative assessment and the use of adjuvant therapy through to potential complications of acute pain management with questions to test yourself throughout.

Background

Chronic pain is defined as pain which lasts beyond the ordinary duration of time that an insult or injury to the body needs to heal, or pain lasting more than three months (1). Patients living with chronic pain may present to hospital as an emergency, with acute pain concerns, or electively, where forward planning of postoperative management can be particularly helpful.

Mechanisms for chronic pain

Chronic pain is thought to mainly be caused by central and peripheral sensitisation.

Central sensitisation

This involves an amplification of the pain signal from nociceptors to the spinal cord. This occurs by the N-methyl-D-aspartic acid (NMDA) receptor at the dorsal horn undergoing a structural change (phosphorylation) which leaves it more excitable, and therefore, it is activated by signals that would usually be below the pain threshold (2,3)

Peripheral sensitisation

This is a result of inflammation at the peripheral nociceptors, the inflammatory response has two effects, the first is to directly activate the nociceptor and cause pain and the second is to sensitise the cell so that it is hypersensitive to further painful stimuli (2).

Case Study

Your patient is a 52 year old lady living with chronic pain; she is being admitted for elective spinal surgery for posterior fusion of the lumbar spine and sacroiliac joints. The surgery is intended to ease chronic back and hip pain.

Pre-operative assessment

Identifying your patient's analgesic history is vital. Preoperatively, the patient's medication should be prescribed as normal, orally where possible.

Table One demonstrates the analgesic requirements for your patient.

Regular analgesia		
Oxyodone-SR	80mg	Once in the morning
Oxycodone-SR	60mg	Once in the evening
Pregabalin	300mg	Twice daily
Amitriptyline	10mg	Once daily
Oral morphine Solution 10mg/5ml	20mg	Seven times daily

Table 1

Perioperative management

A multimodal approach to analgesia is used in addition to the recognised WHO pain ladder (Figure One).

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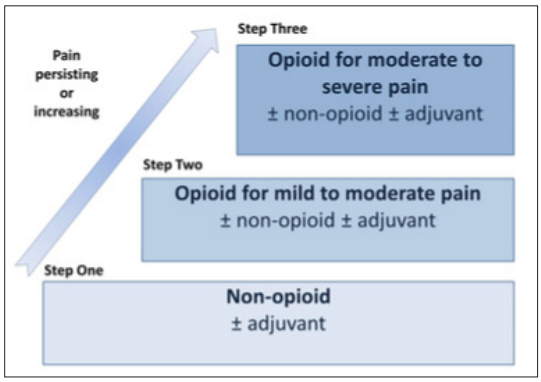
Figure One (4)



The following adjuvants were used perioperatively, it is important to note that the acute pain team within your hospital will be able to advise you on the use of these medications:

1. Magnesium

• 20mmol magnesium sulphate IV.

• Used to reduce opioid requirements in opioid-tolerance or when a patient is on high opioid doses. It works as an NMDA-receptor antagonist (5,6).

2.Ketamine

• 50mg + 10mg + 10mg ketamine IV.

• Ketamine also acts as an NMDA inhibitor. It may be used in subanaesthetic IV doses in the perioperative period, generally for patients whose pain may be difficult to manage with opioids alone. It has been shown to reduce postoperative opioid requirements in patients on long term opioids. Intraoperative ketamine reduces perioperative opiate consumption in opiate dependent patients with chronic back pain undergoing spinal surgery (7).

3. Clonidine

• 75mg + 75mg clonidine IV

• As an alpha 2 agonist, the exact mechanism as an analgesic is uncertain, clonidine has been shown to reduce postoperative opioid analgesic requirements (8,9,10).

Question One: Which mechanism of chronic pain do magnesium and ketamine target?

Further to the above adjuvants, regional anaesthesia including intrathecal or epidural blocks and peripheral nerve blocks can be used in other surgical procedures. These are always beneficial in order to reduce high opioid doses, and associated risks. One additional risk in chronic pain is a paradoxical increase in pain with opioids, resulting in hyperalgesia and allodynia following surgery, further emphasising the importance in adjuvant therapy (11).

Postoperative care

Oral analgesic medication should be continued as normal where possible with route alterations only if patient is nil by mouth or has poor pain control. If alterations are required:

• Calculate the Oral Morphine Equivalent (OME). Figure 2 is a guide to aid this.
• For IV medications, give a half of this OME;
to then titrate up to the full OME if required.
• It is always safest to start with a lower opioid dose and titrate up.

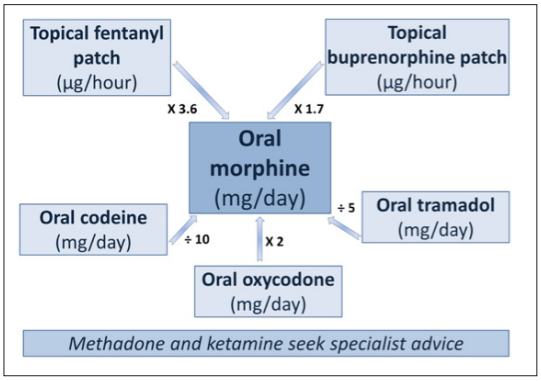


Figure 2 (12)

Question 2: What is your patient's Oral Morphine Equivalent (OME)?

Add short-acting opioids to cover acute pain, the use of Patient Controlled Analgesia (PCA) has been shown to reduce patient anxiety and improve patient satisfaction and your patient's OME can easily be given via this route (13,14). The hospitals acute pain should be able to help with PCA prescription and administration.

CHRONIC PAIN IN THE ACUTE ELECTIVE SURGICAL SETTING

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Question Three: Which opioid should you prescribe for postoperative analgesia?

a)What total dose should you prescribe daily for background pain?

b)What dose should be given for breakthrough pain?

Question Four: Your patient cannot take oral medication and requires an IV alternative, she is anxious about her analgesia as she has had some delayed doses on the ward. What would you prescribe?

Ketamine can also be continued post-operatively as an infusion at a rate of 0.1mg/kg/hour for up to 24 hours. It is often best to seek advice from the acute pain team about local hospital policy for ketamine infusion.

If patients take a gabapentinoid regularly, this should be continued. Gabapentinoids also reduce the dose of opioids required and reduce incidence of chronic post-surgical pain if used only in the acute setting. If gabapentinoids are prescribed for acute pain only, these should be gradually stopped prior to discharge (15).

Potential problems

• Postoperative fever can increase drug absorption via patches therefore monitor patients closely for opioid side effects (16, 17).
• Respiratory depression is always a risk when prescribing high dose opioids and therefore respiratory rate, pupil size and GCS must be monitored frequently.
• Serotonin syndrome, an increase in serotonergic activity, can be life-threatening (18). The main risk in a perioperative patient is the interaction of a Selective Serotonin Reuptake Inhibitor (SSRI) alongside tramadol. It is a clinical diagnosis and most cases present within six hours of a change in medication. Potential symptoms are seen in Figure Three (18). Treatment includes:

1) Discontinuation of SSRI

2) Supportive care

3) Benzodiazepine sedation

4) Serotonin antagonists

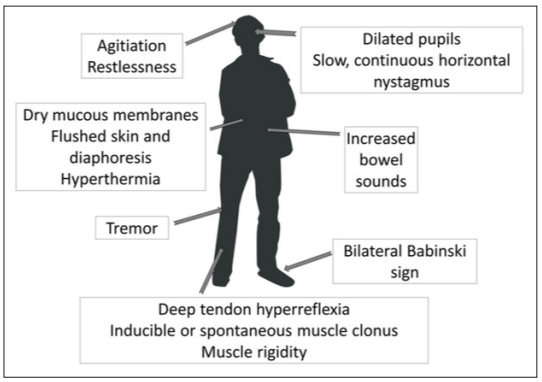

Figure 3: Symptoms of serotonin syndrome.

Patient expectations

Patient expectations can have a significant impact on their pain experience and recovery. These concerns should be addressed as early as pre-operative assessment with a pain management plan being developed. The main aim is to explain to the patient:

1) It is neither likely nor safe to reduce pain to a level below their baseline following surgery.

2) The rationale for use of alternative analgesia.

3) Recovery can take weeks to months, during which time pain may continue to be a problem.

Poor communication with the patient postoperatively may delay recovery and the acute pain team should be involved early in the postoperative period. The team should encourage the patient to take an active role in recovery to enable early mobilisation.

Summary

• Maintain all usual medications during admission, and dose convert patients if requiring different preparations of medicines.
• Careful use of adjuvant therapy can reduce the need to use high dose opioids, thus reducing the associated risks.
• Managing patient expectations is crucial with frequent discussions before and after surgery whilst providing patients with the opportunity to be involved in decision making.
• It is always best to request the advice of the acute pain team within your trust when prescribing adjuvants or changing opioid prescriptions.

Answers

Question 1

Magnesium and ketamine are NMDA receptor antagonists, thus reducing the effects of central sensitisation of pain.

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Question 2

Oxycodone total = 80 + 60 = 140mg/day x 2 = 280mg/day oral morphine.
Oramorph = 20 x 7 = 140mg/day oral morphine.
Total OME = 420mg/day.

Question 3

Oral oxycodone-SR should be selected because this is the patient's usual analgesic agent.

a) The patient's usual dose of oxycodone SR should be prescribed; this would be 140mg/day.

b) Breakthrough pain should be given at 1/6th the total dose; this would be approximately 24mg of oxycodone SR, given in 20mg tablets to round down the dose.

Please note, all calculations are a guide, it is always best to provide a lower opioid dose and titrate up. Always contact the acute pain team if uncertain about prescribing analgesia.

Question 4

An oxycodone PCA can be used for IV analgesia, or when a patient requires greater control of administration; changing to IV analgesia requires more caution once again. Oxycodone would be given as it is the patient's usual form of analgesia, and PCA is a good option for IV analgesia in chronic pain.

Also of note, the patient in the case study received 1mg/hour PCA, in addition to her oral oxycodone SR. A 1mg/hour oxycodone PCA gives a maximum of 24mg/day for breakthrough pain, equal to the 1/6th of total dose for PRN pain. The PCA was also increased to 2mg/hour the next day demonstrating the method of starting low and titrating up as required. This gave a total dose of IV oxycodone of 48mg/day. This patient was requiring high doses of opioids, and the increase in PCA demonstrates how one must individualise each patient's analgesia.

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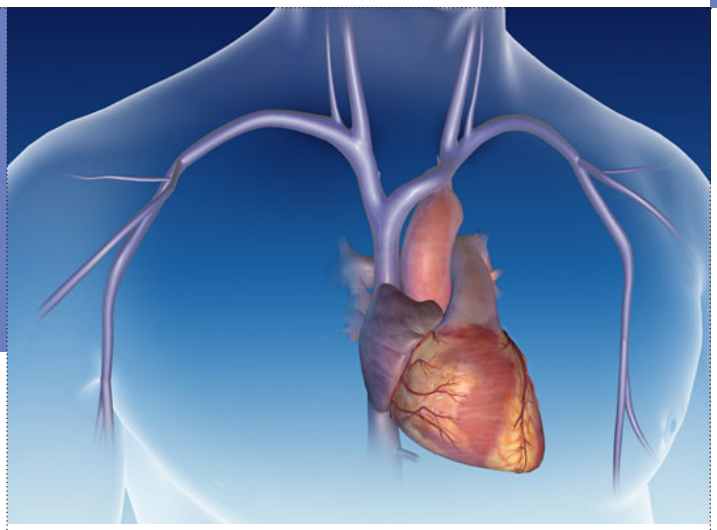
CENTRAL VENOUS ACCESS

J Rivers, S Linter



Central Venous Access
Practical Procedures

By the end of the article, the reader should be familiar with best practice for inserting and looking after central lines and the complications associated with them.

Summary

Central venous catheterisation is performed commonly in modern practice for a variety of clinical indications. A range of catheters is available and the most suitable catheter should be selected for the insertion indication. Significant morbidity is related to the use of CVCs and may be reduced by correct procedures at insertion and throughout the duration of use.

Introduction

Werner Forssmann, a surgical resident in Germany in 1929, took a long catheter used for kidney operations, made an incision in his median cubital vein and threaded the catheter through the opening until he thought the tip would be near his heart. While holding the catheter in place, he walked to the radiology department and took an X-ray that revealed the catheter tip was in his right atrium. Since this, the first recorded episode of central venous catheterisation in humans, the pro-cedure has become commonplace in clinical practice. Historically central venous access was gained by a cut down procedure, but now the most common method is the percutaneous needle-guide wire- catheter method first described by Seldinger in 1953 (1).

A central venous catheter (CVC) is a catheter with a tip that lies within the thoracic part of the vena cava (specifically the proximal third of the superior vena cava, or inferior vena cava) or the right atrium. No valves lie between the catheter tip and the right atrium. They may be inserted either through a peripheral vein (a peripherally inserted central catheter-PICC), or central vein.

The most common central sites of insertion are the internal jugular, subclavian, and femoral veins. In 1994 an estimated 200,000 central venous catheters were inserted in the UK (2). In the USA 5 million are inserted annually. Anaesthetists are among the medical professionals most often involved in their insertion, though they may be inserted by doctors in other specialties, or increasingly specialist nurses. Insertion is not risk free and around 15% of patients may suffer a complication related to their CVC (3).

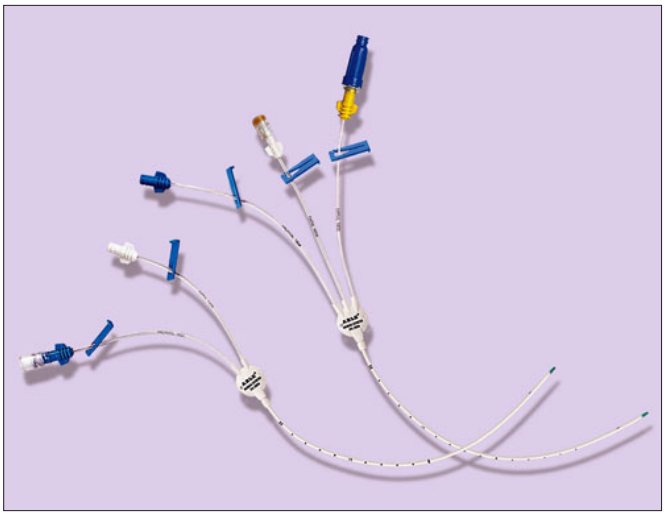


Figure 1: Examples of central venous catheters.

Indications for central venous catheterisation

Access for IV drugs

- *Parenteral nutrition*
- *Difficult peripheral access*
- *Irritant drugs*
- *Vasoactive drugs*
- *Long term drugs*

Access for extracorporeal circuits

- *Renal replacement therapy*
- *Plasma exchange*
- *ECMO*

CENTRAL VENOUS ACCESS

J Rivers, S Linter

Monitoring

Central venous pressure or oxygen saturation

Interventions

Repeated blood sampling
Transvenous cardiac pacing

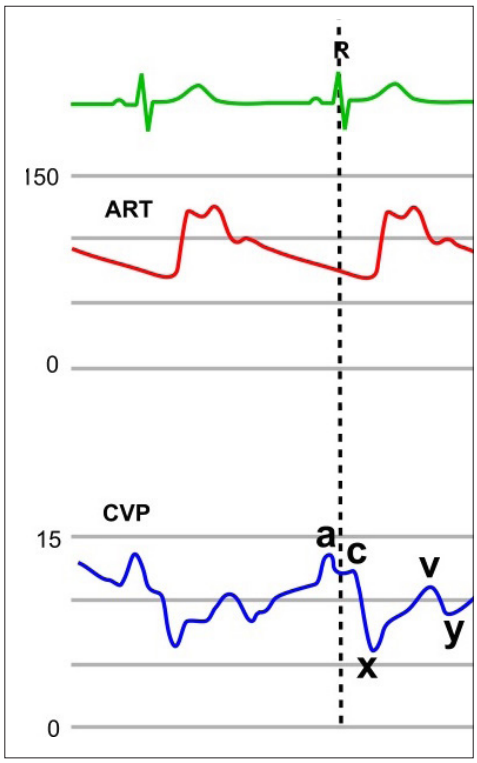


Figure 2: The normal central venous pressure trace, and corresponding arterial and ECG trac-es.

The CVP trace is significantly lower in pressure than the arterial trace. Image reproduced from (4):

A wave; *due to atrial contraction. Absent in atrial fibrillation. Enlarged in tricuspid stenosis, pulmo-nary stenosis and pulmonary hypertension.*

C wave; *due to bulging of tricuspid valve into the right atrium or possibly transmitted pulsations from the carotid artery.*

X descent; *due to atrial relaxation.*

V wave; *due to the rise in atrial pressure before the tricuspid valve opens. Enlarged in tricuspid regurgitation.*

Y descent; *due to atrial emptying as blood enters the ventricle.*

Canon waves; *large waves not corresponding to a, v or c waves. Due to complete heart block or junctional arrhythmias.*

Catheter Selection

There are many different kinds of CVC, and the particular catheter that is chosen for insertion into a patient should be based on consideration of the site of insertion, the duration of use and the reason that the catheter is required. In anaesthesia and critical care the main considerations are the length of the catheter and the number of lumens. If rapid infusion is required, then a shorter catheter with a wide lumen diameter is needed (such as an 8.5fr introducer sheath). Multiple small lumens generally do not allow rapid infusion, but the number of drugs that can be infused at the same time is increased. The dead space is also reduced, which may be preferable, if using potent or vasoactive drugs. In intensive care, catheters with 3-5 lumens are generally inserted. Lengths range from approximately 12-20cm.

Catheter types

Single / multi lumen catheters
Dialysis catheters
Peripherally inserted central catheters (PICC)
Tunnelled
Portacaths

Catheter insertion

The basic principles of CVC insertion are similar whatever the catheter type or site of insertion is chosen. Insertion should take place in a suitable clinical area where sterility may be maintained. The presence of a trained assistant is required, and the patient should be monitored with ECG, BP, and O_2 saturations. A pre stocked dedicated lines trolley may increase the likelihood of adherence to best practice. The procedure should be explained to the patient and informed consent obtained.

A strict aseptic technique should be followed. The skin of the insertion site and surrounding area should be prepared with 2% chlorhexidine and 70% isopropyl alcohol. Central venous access has traditionally been achieved by puncturing the intended vein by passing a needle along its anticipat-ed line, using surface anatomical landmarks, and knowledge of the expected relationship of the vein to its palpable companion artery. This is known as the 'landmark method'. Ultrasound is in-creasingly being used to guide the needle into the vein in real time.

In general, once the insertion point has been located, either by the use of ultrasound, or land-marks, a needle mounted on a syringe is inserted through the skin and advanced into the vein, as-pirating as it is advanced. Once blood is freely aspirated, the syringe is disconnected from the needle taking care not to move the needle tip, and a guide wire is advanced through the needle into the vein. The needle is then removed, the wire remaining in the vein. A dilator is then passed over the guide wire to the skin surface and a small skin incision is made to allow passage of the dilator through the skin and into the vein. The dilator is then removed over the wire whilst using gauze to apply pressure to the skin to reduce bleeding. The catheter is passed over the wire and the wire is withdrawn until it protrudes from the proximal end of the catheter. The catheter is ad-vanced into the vein and the wire withdrawn.

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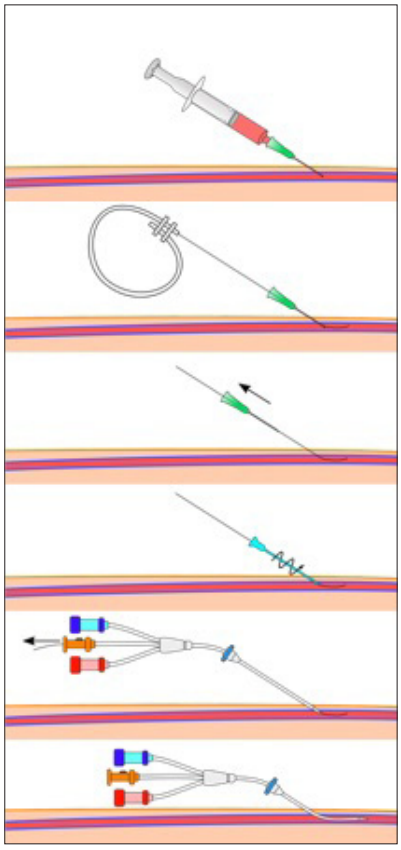

Figure 3: Seldinger technique for central line insertion. Image from (5).

Anatomy and approach for common insertion sites

The internal jugular vein

The internal jugular vein arises from the sigmoid sinus in the base of the skull, and passes from the jugular foramen, to descend within the carotid sheath in the neck, to a point behind the medial end of the clavicle, where it joins the subclavian vein to form the brachiocephalic vein. It is closely re-lated to the carotid artery and vagus nerve.

The patient is positioned head down with arms by the sides and head turned away from the side of insertion. The entry point of the needle is midway between the mastoid process and the sternal notch, it is advanced at 30-40 degrees to the skin in the direction of the ipsilateral nipple.

The femoral vein

The femoral vein begins at the saphenous opening in the thigh, and passes upwards to the ingui-nal ligament alongside the femoral artery where it becomes the external iliac vein.

The patient is positioned supine with the leg externally rotated. The femoral artery is palpated 2cm below the inguinal ligament, and the needle insertion point is 1cm medial to this. The needle is ad-vanced cephalad at an angle of 20-30 degrees to the skin.

The Subclavian vein

The subclavian vein is the continuation of the axillary vein after it has passed the lateral border of the first rib. It runs behind the clavicle to join the internal jugular vein and form the brachiocephalic vein.

The patient should be positioned head down. The needle insertion point is at the junction of the middle and medial thirds of the clavicle, and it is advanced in a horizontal plane behind the clavicle aiming for the sternal notch.

Usage of ultrasound

A 2002 guidance document produced by NICE recommended the use of ultrasound for the elective insertion of CVC's into the jugular vein. They noted that whilst experienced operators achieved high rates of success using landmarks, the failure rate overall could be as high as 35%. They ex-amined seven RCTs which suggested that real-time 2-D ultrasound guidance was significantly better (than the landmark method) for all the outcome variables measured, for insertions into the IJV in adults.

Compared with the landmark method, 2-D ultrasound guidance was associated with re-duced risks of failed catheter placements, catheter placement complications, and failure on the first catheter placement attempt and fewer attempts were needed to achieve successful catheterisation (6). The needle passage into the vessel can be viewed out of plane (vessel imaged in the transverse plane) or in-plane (vessel imaged in the longitudinal plane). An expert consensus group concluded that, no one view is better than another, and a combination of the two may be optimal (7).

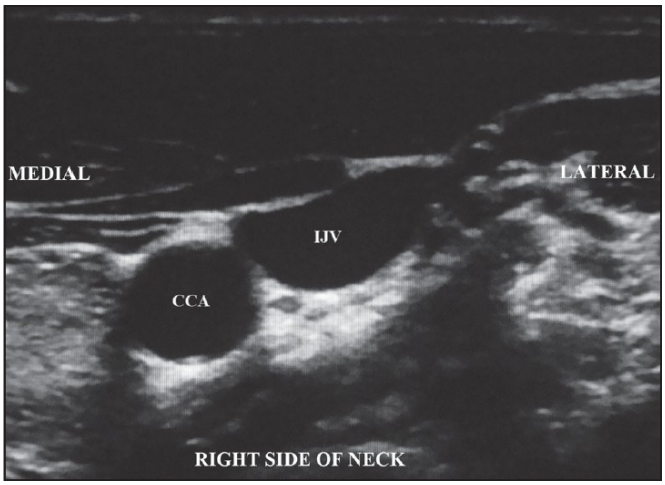

Figure 4: Ultrasound image of the neck showing the common carotid artery (CCA) and in-ternal jugular vein (IJV). At this level the vein is laying anterolateral to the artery. Image re-produced from (8).

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Confirming catheter position

Confirmation of venous rather than arterial vessel puncture, or cannulation, can be achieved using direct visualisation at the time of insertion with ultrasound, pressure transduction confirming a ve-nous pressure wave, or paired arterial and venous oxygen saturations. A chest radiograph should be requested post procedure to confirm tip position, and to exclude pneumothorax. The CXR is not useful in distinguishing arterial from venous placement.

In most patients, expert consensus is that the tip of the catheter should lie parallel to the wall of the vessel, above the pericardial reflection such that the tip does not abut the vein or heart wall at an acute angle or end on. The line, when viewed on the chest radiograph should have its tip just above the level of the carina. This ensures that the tip lies outside the right atrium and reduces the risk of perforation and of tamponade should this occur.

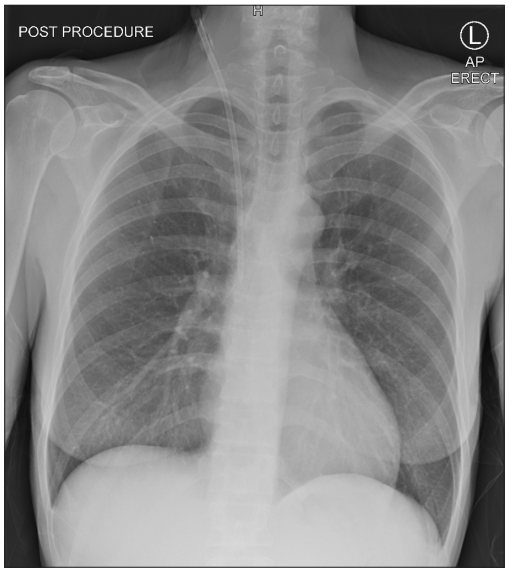

Figure 5: X ray showing a right internal jugular central line. In this case, the tip lies just be-low the carina. Image reproduced from (9).

Complications of CVC insertion.

Complications may be divided into early and late, and subdivided into mechanical, infectious, and thrombotic. Correct technique at the time of insertion may reduce many of these complications.

Mechanical	Infectious	Thromboembolic
Arterial puncture	Local infection	Thrombosis
Haematoma / bleeding	Sepsis	Air embolism
Pneumothorax		Vessel stenosis
Arrhythmias		
Thoracic duct injury		
Nerve injury		
Erosion through wall		

Table 1: Complications of CVC insertion.

Infective complications

Nosocomial blood stream infections are associated with increased morbidity, mortality, ICU and hospital length of stay, and carry significant economic costs (9). CVC's are most often colonised by skin commensals such as coagulase negative staphylococci, but also enterococci, and staphylococcus aureus. Colonisation may occur at or soon after insertion, by the passage of organisms along the line or line tract, or by haematogenous spread from a distant source. Diagnosis of a CVC line infection may be difficult as clinical signs such as inflammation or pus at the site of insertion, are unreliable. The diagnosis should be considered in a patient with a CVC who has a fever with-out other cause. Positive blood cultures for an organism known to colonise CVCs should raise suspicion.

A bundle of interventions was found to be successful in reducing the rate of blood stream infections associated with CVCs in Michigan, USA. The interventions comprised hand washing, full barrier precautions, skin preparation with chlorhexidine, removing unnecessary catheters, and avoiding the femoral site where possible. The UK used a similar approach in a stepped intervention pro-gramme, matching Michigan, and achieved a marked reduction in CVC related BSI (10).

Thrombotic and occlusive complications

CVC occlusion and catheter related thrombosis (CRT) are common complications, especially in patients with long term central venous catheters. Occlusions may be complete, such that neither aspiration nor infusion is possible or partial where infusion remains possible. A fibrin sheath may form a flap valve at the end of the CVC which occludes on the negative pressure of aspiration . Thrombosis may form in the catheter lumen causing occlusion, or precipitation of medication may occur. Once a catheter is occluded, it may be possible to unblock with specific treatment, such as intra catheter thrombolysis for thrombus (11).

Thrombosis may also occur outside the catheter, at or around the site of insertion. Most catheter related thrombosis are asymptomatic but where symptoms occur, they include pain, tenderness to palpation, swelling, oedema, and erythema. Collateral veins may be dilated. Once a catheter relat-ed thrombosis has occurred, consideration will need to be given to catheter removal, and antico-agulation. The correct management in this situation is controversial and will depend on the individ-ual patient's circumstance, and their ongoing need for central venous access.

Self assessment questions:

1.When looking at a CXR, the tip of a right sided Internal jugular catheter should be located:

a. below the level of the carina
b. above the level of the clavicle
c. just above the level of the carina
d. below the diaphragm

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2. What site of line insertion and what complication is shown in the following chest radiograph (image reproduced from 12)

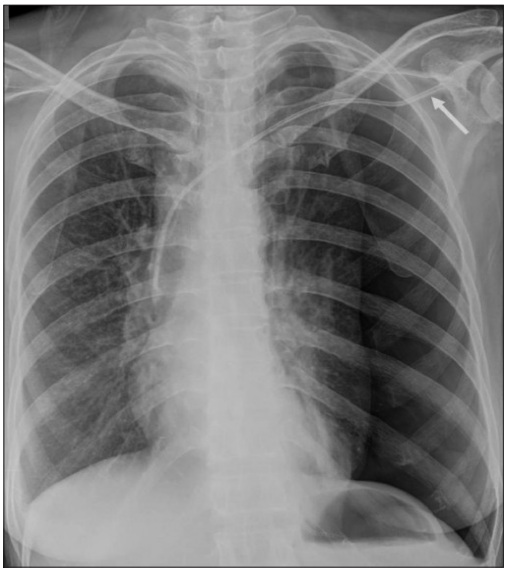

Figure 6

3.Concerning prevention of catheter related sepsis (CRS);

a: The use of the subclavian route carries the lowest risk of catheter related sepsis.
b: Central venous catheters are never colonised by enterococci.
c: Standardised care bundles can help reduce the incidence of CRS
d: CRS is easy to diagnose.
e: CRS is associated with longer hospital stays.

4.Regarding the CVP waveform;

a: The A wave is due to atrial contraction.
b: The C wave is due to ventricular contraction.
c: The X descent is due to atrial relaxation.
d: The V wave is enlarged in tricuspid regurgitation.
e: The Y descent is due to atrial emptying as the mitral valve opens.

Answers

1: c
2: Left subclavian CVC complicated by left pneumothorax
3: T, F, T, F, T
4: T, T, T, T, F

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COMPETENCE, COMPLICATIONS & CONSENT IN ANAESTHESIA

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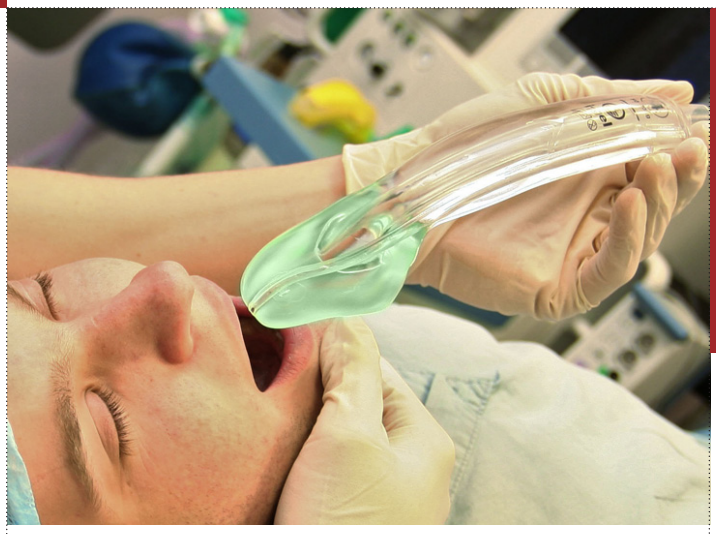


Competence, Complications & Consent in Anaesthesia
Patient Management

Abstract

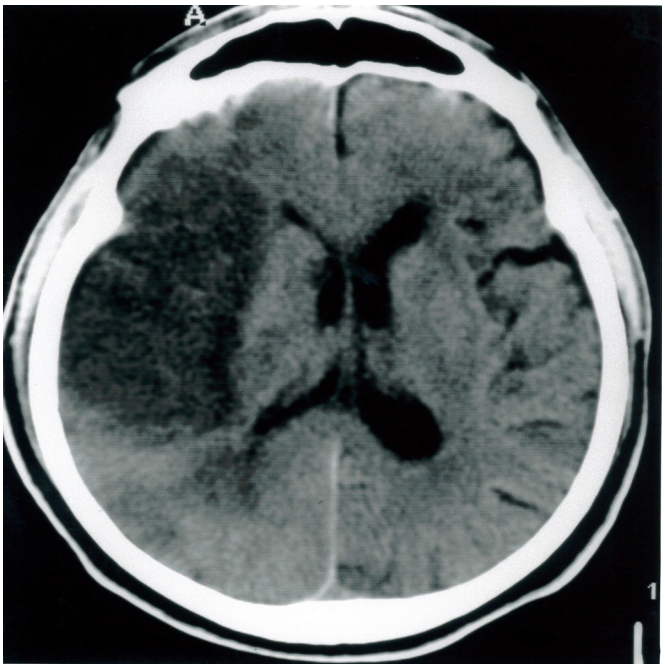
Anaesthesia carries the potential to cause death or serious injury, risks which the patient should be made aware of. This paper explores contemporary standards of informed consent and the difficulties in achieving this within anaesthesia.

The issue of competence in technical interventions as a specific component of consent is highlighted by a tale from civil litigation which demonstrates adverse consequences for both patient and practitioner.

Clinical Vignette

A 72-year-old gentleman undergoing revision aortic aneurysm surgery had an attempted placement of a central venous catheter pre-operatively. Unfortunately, a large dual-lumen dialysis catheter was inserted into the carotid artery under ultrasound guidance by a registrar anaesthetist. Misplacement was identified at the point of aspiration and the line was removed with subsequent application of local pressure.

Surgery was postponed and the patient recovered from anaesthesia at which point a contralateral neurological deficit was identified. The patient was left with permanent disability and initiated civil proceedings against the Trust claiming a breach of duty with regards to technical competence for the procedure and a failure to ensure informed consent for this intervention. The claim was settled at an early stage in favour of the patient.



Introduction

Anaesthesia carries the risk to the patient of death or serious injury through a range of mechanisms, and an accompanying jeopardy for the responsible practitioner. There is a trend in litigation to bolster a 'breach of duty' allegation in relation to complications with the claim that consent fell below contemporary standards and the patient would never have agreed if they had been adequately informed of the risks. This strategy, which can generate a viable case even if the injury itself is ultimately accepted as a known risk materialising non-negligently, has gained momentum following certain landmark cases based on consent.

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The goal of this paper is to explore contemporary standards of consent, particularly when applied to technical interventions for which a junior doctor may not have achieved the highest standards of competence, an issue which clearly goes beyond the specialty of anaesthesia. The hurdles to achieving fully informed consent within anaesthesia will also be discussed, along with the consequences that arise for practitioners who are found to be non-compliant with defined expectations.

Consent: from historical principles to recent legal cases and current standards

The concept of consent goes back over 2000 years to the time of Plato, when intellectuals considered choice fundamental to being a 'free person'(1). This principle in relation to medical intervention was consolidated in English case law in 1767 following Slater vs Baker where the court found the surgeon's decision to break and reset Slater's healing fractured leg unacceptable without the patient's consent for this experimental approach(2).

However, consent at that time simply represented agreement to the actual procedure rather than being based on a broader discussion of benefits, risks and alternatives. The concept of 'informed consent' followed litigation in the American courts in 1957, Salgo vs Leland Stanford Jr. University Board of Trustees, based on failure to warn of the risk of paraplegia after aortography. The court deemed this lack of communication unacceptable, and a crime in its own right, i.e. distinct from a charge of battery as in previous cases where there had been no consent to the actual procedure(3).

The Bolam test however continued to dictate standards of consent within UK clinical practice whereby practice was considered defensible if it conformed to that adopted by a reasonable body of practitioners (4). This radically changed in 2004 following the case of Chester vs Afshar (cauda equina syndrome after spinal surgery), in which it was found that the patient would not have gone ahead with surgery on that particular date if she been provided with information on risks which she should have been made aware of (5).

Absolute displacement of the Bolam test was confirmed in 2015 following the Montgomery vs Lanarkshire Health Board judgment (6). Mrs Montgomery gave birth to a brain-damaged son following complications of shoulder dystocia, information on which had been withheld by her obstetrician who feared this would influence her towards caesarean section (7). The current legal standards are explicit: 'The test of materiality is whether, in the circumstances of the particular case, a reasonable person in the patient's position would be likely to attach significance to the risk, or the doctor is or should reasonably be aware that the particular patient would be likely to attach significance to it' (8).

These legal standards are paralleled by guidance from the regulatory and specialty professional bodies emphasising that information regarding risk is not a matter for the doctor's discretion (9). The following sections consider the implications of these judgements for anaesthesia and technical interventions in general.

Crystallising the core components of anaesthesia in relation to consent

Anaesthesia has no intrinsic therapeutic value, being conducted solely to facilitate surgical intervention, and carries a number of risks at every stage of the process. Whilst refinement of anaesthetic agents, equipment, ability to monitor most physiological variables, and professional standards, has lead to a high level of safety over the last three decades, increasingly heroic surgery on an ageing population with multiple comorbidities continues to generate both challenge and risk.

That risk includes post-operative organ failure or complications such as pneumonia or thromboembolic disease, despite flawless anaesthetic technique. Even the fit patient undergoing minor surgery is vulnerable to unanticipated anaphylaxis, a failure to achieve the desired goals including oesophageal intubation or awareness, complications of technical interventions such as that described, pneumothorax, cervical spine injury or dental damage, errors of drug administration, or failure to diagnose and appropriately manage emerging problems.

The primary goal of the anaesthetic assessment is to assess the overall risk to life generated by the patient's health status in the light of the proposed surgery and anaesthetic technique. The secondary goal is to define an appropriate anaesthetic technique which is understood by and acceptable to the patient. Herein lies the nub of this whole debate, since this represents an enormous amount of detail for an intervention over which the patient has very little control once they have agreed to the proposed surgery. It can be argued that most patients would want an accurate determination of peri-operative risk in the light of their health status, an understanding of why a particular anaesthetic technique was being recommended such as regional rather than general anaesthesia, and information on post-operative expectations such as pain management, nausea and mobilisation.

It could be reasonably assumed that most patients would want reassurance that the practitioner had the competence to identify the risks at different stages and avoid all of the above complications, rather than providing an exhaustive list of complications which does not provide reassurance and arguably does not assist in decision-making, potentially introducing fear and irrationality into a scenario over which the patient has little choice. So should patients have the risks of each component of the anaesthetic process set out as the principles derived from litigation and the specific vignette suggest?

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There is no expectation on the surgeon to break down every component of operative technique and seek consent to each aspect on the basis of the specific risks at that particular point. Once the patient has agreed to a particular procedure, they are not then in a position to accept or decline certain components, since this would render the proposed surgery unworkable, and logically this principle could and should be applied to the process of anaesthesia.

The pragmatic way to interpret these directives is that interventions which are optional rather than intrinsic to technique, such as placement of an epidural catheter for post-operative pain relief, or as in this case, a large-bore central venous catheter, and which carry documented significant risks, must be subjected to a detailed and identifiable form of consent. The interplay between competence and consent is highlighted by the vignette and is expanded upon below.

The issue of competence as a component of consent

Whilst experience is time-cumulative and therefore on a spectrum, expertise or competence can be considered more of a binary phenomenon with an accompanying responsibility as defined by the GMC for every doctor to recognise the limits of that competence (10). The decision in this particular case to insert a central venous catheter for either pressure monitoring or administration of vasoactive drugs, was justifiable. The decision to insert a large-lumen catheter for the rapid administration of fluid should this be required was justifiable, but only if this could be conducted competently, since theoretically rapid transfusion could be achieved equally well via large-lumen peripheral catheters.

The significant risks associated with carotid artery puncture during attempted central venous catheterisation via the internal jugular vein have been well documented for some time (11), will predictably be higher in elderly patients with established vascular disease (such as the patient in our vignette), and have been the driver behind national recommendations for the use of ultrasound since 2002 (12). To progress from initial cannulation, through guide wire insertion and dilatation, to insertion of a dialysis catheter into the carotid artery, in the elective rather than emergency situation, does not equate with competence in central venous catheterisation, with or without the use of ultrasound.

The key question is whether that lack of competence should have been identified and acknowledged by the practitioner, as per the GMC guidance, prior to embarking on a technique which would have such catastrophic consequences. It could be argued that since there was no formal assessment of competency in central venous catheterisation at the time of this incident, a situation which still pertains, that the trainee was not under any obligation to declare a lack of formal competency.

Under the fundamental responsibility to identify limits of competence, there would however be a duty on any doctor to inform a patient if they were on a 'learning curve' with regards to a specific intervention which carried significant risks related to the position of the practitioner on that particular 'learning curve'.

Without that aspect being part of the process of consent it remains open to the patient in the event of an adverse outcome to state that if they had been made aware of the significance of the risk and less than full competence on the part of the practitioner, they would have requested either time to reflect on those risks or the involvement of a practitioner with the requisite competencies, thereby avoiding this specific risk at that time.

Using the legal 'test of materiality', breach of duty and causation as the core constituents of negligence thereby become proven, and litigation succeeds. We can therefore start to define which aspects of information are relevant to consent within anaesthesia, but a number of practical barriers still remain.

Practical feasibility of achieving consent

Informed consent goes beyond a list of risks and mandates the opportunity for the patient to explore and reflect on the information provided, followed by time for further questions before confirmation that they are willing to proceed. There are so many variables in this process, along with logistical hurdles, that questions can be raised as to whether truly informed consent is ever achievable.

The pre-assessment clinic is likely to be run by nurse practitioners who will not be responsible for anaesthetic delivery, and who do not therefore determine the anaesthetic technique, do not have the knowledge base to derive predicted peri-operative morbidity and mortality, and are not in a position to comment on the experience or expertise of the eventual anaesthetist for a specific intervention.

Although a wealth of information booklets are available from the professional body (13), these will never have the focused relevance of the responsible anaesthetist taking the patient through the above process. A major barrier to consent arises when the patient is admitted on the day of surgery, to see the actual anaesthetist shortly before the procedure, often without either the privacy or the time to explore questions, proposed changes in technique, or additional variables created by differing levels of experience and expertise.

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Finally, the dilemma of documentation of this process arises, a complex balance between the standards expected for the surgical procedure and professional guidance that consent for anaesthesia does not need to be similarly formalised (14). As the vignette illustrates, if there is no evidence that issues which fall within the 'test of materiality' have been the subject of discussion, the practitioner will be vulnerable in any subsequent litigation, despite all the above intrinsic difficulties and practical issues such as the inevitable diversion of time for comprehensive documentation.

Conclusions and key recommendations

The concept of informed consent has received tangible endorsement within recent case law and will inevitably be exploited by legal teams specialising in clinical negligence. Complications of interventions will not be simply accepted as known risks materialising, but will be plotted against standards of competence, which in turn will be plotted against contemporary standards of informed consent. Anaesthesia is a complex amalgam of goals, drugs, monitoring and interventions over which the patient has little choice once a decision has been made to embark on a surgical procedure.

Despite this complexity and a number of hurdles to achieving informed consent, particularly with the current pattern of admission on the day of surgery, the specialty is not immune to the current consent standards for medical practice as a whole. In the event of an adverse outcome, practitioners will be expected to demonstrate that they identified the overall risks for that specific patient, explained the risks and benefits of the chosen technique for that particular surgical procedure, set out any variables which influenced that risk such as experience and competency, and gave the patient time to reflect on this information and ask questions before registering their consent.

These principles naturally apply to all disciplines and provide a reminder of the implications for the professional reputation of a practitioner if compliance with these principles cannot be evidenced from the medical records. It is not our intention to derive a blueprint for consent for all potential scenarios, but to simply highlight the current status of legal scrutiny of complications. As such, our recommendations are simply to be cognisant of professional responsibilities and ensure compliance with departmental and national policies.

As a practical pointer, the senior author documents on the anaesthetic record that he has asked the patient if they have any residual questions or concerns immediately prior to commencing anaesthesia and hopes that this conveys compliance with anticipated standards in the event of future scrutiny. The broader implications for society if practitioners avoid certain interventions because of the significant time investment required for fully informed consent and the professional jeopardy if complications materialise without such evidence, are beyond the scope of this article.

Multiple choice questions

1. When performing venepuncture at the antecubital fossa I must...

a) Obtain signed written consent from the patient

b) Discuss my reasoning for venepuncture in a way that the patient understands and let them make their own decision regarding whether blood is taken or not

c) Always inform a senior that I have taken blood in case of litigation

d) Show them the needle and wait for them to roll up their sleeve

2. Which of the following is not a consideration when obtaining informed consent?

a) The patient must make the decision freely

b) The patient must have capacity

c) The patient must be aged 18 or over

d) The patient must be given all the relevant information

3. In which of the following scenarios is obtaining the patient's consent the most important?

a) Anaesthetising a patient for neurosurgery

b) In referring a patient to secondary care

c) Starting a patient on statin therapy

d) All of the above

4. Which of the following is not part of taking consent when inserting a CVC?

a) The risk of arterial puncture

b) The benefit of real time ultrasound monitoring and large bore venous access

c) The alternative option of not inserting a CVC and the associated risks of this

d) The exact size, make and model of the CVC which will be inserted

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5. If I'm not sure about consent, where can I find out more?

a) Colleagues

b) GMC website

c) Specific training events

d) All of the above

Answers

1. Answer: B

2. Answer: C

For more information explore Gillick competence and the Fraser Guidelines.

3. Answer: D

Patients should be involved in all decisions made concerning their care.

4. Answer: D

5. Answer: D

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DEPRIVATION OF LIBERTY SAFEGUARDS: A GUIDE FOR JUNIOR DOCTORS

S Carter, A Kulkarni, N Khadim

Deprivation of Liberty Safeguards: A Guide for Junior Doctors
Good Clinical Care

Abstract

Deprivation of Liberty Safeguards (DoLS) are an amendment to the Mental Capacity Act which govern the legality of depriving a patient of their human right to liberty when they do not have the capacity to make decisions regarding their own care and treatment. Additional guidance and clarification surrounding the use of DoLS, created following a Supreme Court ruling back in early 2014, have served to widen the definition of the safeguards and caused a vast rise in DoLS applications.

The advent of the 'acid test' identified patients under continuous supervision and control who are not free to leave their surroundings as being deprived of their liberty. This has been of great consequence to intensive care and is currently the subject of much controversy. Of particular concern, is the issue regarding clarity as to if and when it is appropriate to seek DoLS authorisation when dealing with patients with impaired consciousness secondary to organic disease or pharmacological agents.

Introduction

A number of weeks ago whilst working in our intensive care department, an official looking lady approached me and asked me very seriously, 'What does deprivation of liberty mean to you?'.

In all honesty, I didn't know how best to answer her and just about managed to stutter the age old adage, "err... I'm just the FY1", before she disappeared off mumbling something that sounded suspiciously like "useless" under her breath.

A quick lunchtime Google informed me that Deprivation of Liberty Safeguards (or DoLS to those in the know) are an amendment to the Mental Capacity Act 2005, created to protect the human rights of those vulnerable patients who lack the capacity to consent for treatment and who require limitations placed upon their liberty to keep them safe from harm (1,2).

Background to DoLS

DoLS apply only to patients in hospitals or care homes and are designed for use in situations including:

a) Patients admitted by restraint or sedation,

b) Patients not permitted to be discharged,

c) Scenarios whereby staff have complete control over patient care and treatment (2).

DoLS are not a new concept, coming into force back in 2009 as an extra layer of protection for patients being placed under restrictions or restraint in their best interests under the Mental Capacity Act (3). The rationale behind its creation stemmed from a European Court of Human Rights ruling which found a psychiatric hospital guilty of breaching a patient's right to liberty after preventing him from leaving their unit when he had been informally admitted (4). Our laws at the time were deemed to not adequately protect the human rights of vulnerable patients who were potentially being deprived of their liberty and the need for a system to recognise and protect those patients was identified (2,4).

DoLS allowed the proper administration and regulation of legally depriving someone of their liberty in their best interests when a lack of mental capacity is present. In simple terms, it means that organisations must have a set policy and framework for identifying potential cases with protocols governing how they must act if it is deemed necessary to deprive a patient of their liberty.

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In March 2014, the Supreme Court passed further guidance on the clarification of the definition of deprivation of liberty in a ruling known as the Cheshire West judgment. It followed a lengthy court case surrounding deprivation of liberty issues for three patients with learning disabilities who were unable to consent to their living arrangements. The outcome saw the introduction of an 'acid test' to determine if a patient is being deprived of their liberty (4,5).

This test takes the shape of three questions:

Is the person subject to continuous supervision and control?

Is the person free to leave?

Is the person unable to consent to this deprivation of their liberty?

With the ruling stating, 'to be deprived of their liberty an incapacitated adult must be subject to both continuous supervision and control and not be able to leave their placement. In addition, the area and period of confinement are ingredients of deprivation of liberty' (5).

Factors deemed to be relevant when considering whether deprivation of liberty is occurring:

- *The use of restraint in the admission process*
- *The use of restraint or medication used against the patient's will during their stay*
- *Staff making decisions regarding the patients treatment, activities and contact with visitors*
- *Not being able to leave without supervision*
- *The duration of any restrictions*

Factors identified as not relevant were;

- *The reason or purpose for placement and/or treatment*
- *Patient compliance with treatment*
- *A lack of objection from the patient*
- *Family or carers agreement*
- *The 'normality' of treatment/placement*
- *Lack of alternative place for treatment/placement (4,5)*

Principles for Patients within ITU / Critical care setting

The intensive care setting in particular is the subject of much controversy surrounding the use of DoLS. We care for many patients who due to the emergent nature or severity of their condition cannot provide consent for either their admission or subsequent treatment, meaning we must work carefully within the limits of the Mental Capacity Act (6,7). A quick glance around our unit and only one of the seven patients is aware she is in intensive care and has the capacity to consent to stay. Are the other six truly being deprived of their liberty?

With reference to the acid test:

A) Are they subject to continuous supervision and control?

Yes. Our patients have a nurse with them at all times, that nurse feeds them, washes them, administers medication and even decides if its appropriate for visitors to come in.

B) Are they free to leave?

No. Our patients are not free to leave, not because we are forcibly controlling their movements but because we are administering life saving treatment to enable them the right to live, let alone to liberty. However, in order for us to do this, we may have to turn to restrictive measures (least) including sedation and restraint.

Our patients are unable to leave, if a family member tried to remove them from the unit there would be uproar. Here lies the root of the problem. On paper these patients meet the criteria for deprivation of their liberty but there is no specific guidance for the very unique nature of the intensive care setting.

The Intensive Care Society (ICS) offers some advice regarding this issue, stating that 'intent is important' and 'it is not appropriate to apply the DoLS where sedation is intended to facilitate treatment'.

There are circumstances where patient's liberty is NOT deprived where patients:

- *Have the capacity to decide to be admitted to Intensive Care*
- *Consent to the restrictions applied to them*
- *Gave consent for intensive care admission prior to losing capacity-i.e. prior to surgery*

In addition, ICS also deduce that if there is any element of restraint (physical or chemical), or if sedative agents are used in confused patients then DoLS should be activated. They go on to raise the issue that safeguards are not routinely applied for in these situations and may mean departments are acting illegally making them liable to penalties from the GMC (7).

The reality is this; the future of DoLS in their current existence is under threat with the new proposals from the Law Commission. Bringing about changes in legislation will undoubtedly be a complex and lengthy process. In the meantime it is imperative that we do not neglect our duty of care to our patients to act as their advocate and take action in their best interests. With increasing numbers of patients likely to meet the DoLS criteria due to the Cheshire West ruling, it is important that a dilution effect does not impact upon their quality of care.

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Guidance for Junior Doctors

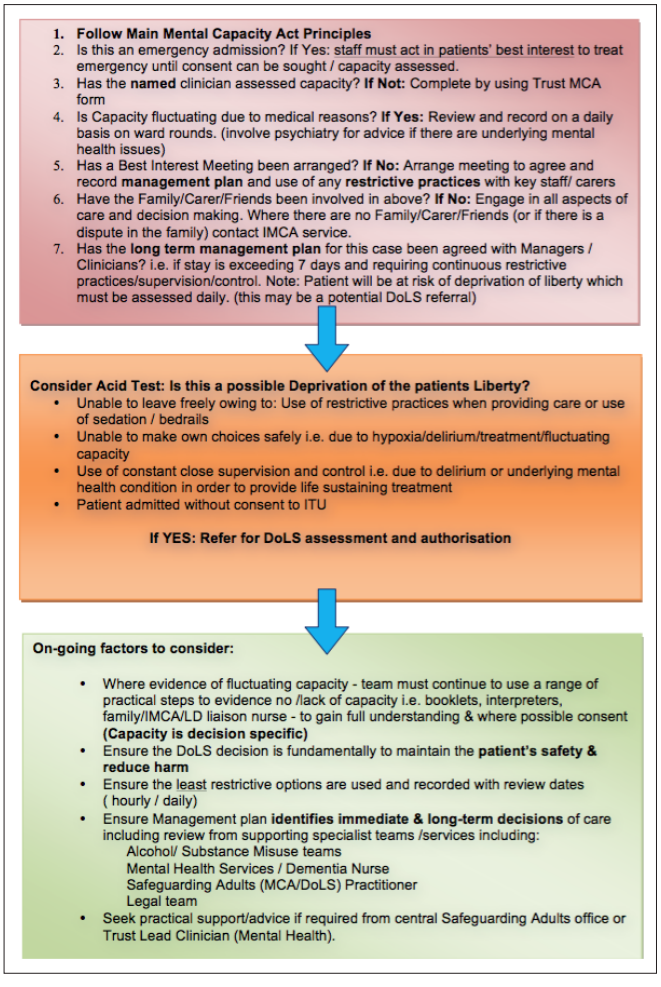
For junior doctors in all specialities it is imperative that we are aware of the role of DoLS and the situations in which it is applicable. With increasing numbers of cases we must be extra vigilant with regard to patient care and appropriate identification of DoLS candidates. Whilst the legal system attempts to provide a sound framework to cater for those patients deemed to be deprived of their liberty, it is advisable to follow advice provided from the Cheshire West judgment and Intensive Care Society guidelines.

Emergency treatment and clinical care should always remain the first priority. The acid test does not apply when treating life saving emergencies as all emergency interventions would always be in the patient's best interest.

The risk of a deprivation of liberty increases with increasing duration of treatment and when initial emergency treatment transitions to on-going care. Such transitions must be considered on an individual patient basis and will be context dependent.

The following flow chart is used in our trust as a guide (8).

ITU MCA/DoLS (Triggers) Flowchart



Conclusion

There is no doubt the creation of DoLS was intended to protect vulnerable patients, however it is clear that additional clarification is required especially in the intensive care setting.

Whilst the advent of the acid test has gone someway to help determine true cases of deprivation of liberty, it is still difficult to be clear on when placing restrictions on a patient crosses over the line into depriving them of their liberty. It has also caused alarm by greatly increasing the number of DoLS applications. As such, the government has instructed the Law Commission to create proposals for the replacement of DoLS with a more comprehensive alternative and be tailored towards the patient setting. (9,10)

Meanwhile, unhelpfully, hospital providers are advised to err on the side of caution and seek legal advice if there is any doubt regarding potential deprivation of liberty. (5)

Case Report and Questions

A 50 year old male (KH) presents to A&E with a GCS of 5/15, BP of 240/122, HR of 140 and SpO_2 70% on 100% oxygen.

On examination he has bilateral crackles on auscultation of the chest and his ECG shows T wave inversion in the lateral leads. Chest X-Ray reveals pulmonary oedema and possible aspiration.

His mother lives miles away and has dementia and he has no other family or friends. His partner (male) informs you that there is possible amphetamine abuse.

Q1) Considering the MCA principles, how do you proceed?

A: The patient does not have capacity to consent to treatment but this is an emergency situation and he requires life saving treatment in A and E. His lack of capacity should be formally assessed and documented and reviewed regularly.

KH is transferred to ITU for treatment of pulmonary oedema and aspiration pneumonia secondary to amphetamine over dose. He is now 10 days into his stay and has undergone tracheostomy insertion. He has been off sedation for a few days and is requiring only minimal respiratory support.

Q2) How do you proceed for assessing the risk for DoLS?

A: With the application of the acid test. Mental capacity must be reassessed as DoLS only apply when capacity is lacking. Consideration must be given to the fact he is in ITU where he is unable to leave, under continuous supervision and did not consent to his admission.

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On review by the ITU consultant, KH has full mental capacity and is requesting for decanulation of his tracheostomy tube and to go home. KH is reassured by the consultants and other staff that this is not in his best interests but he is adamant. A psychiatry opinion is sought who also declare that KH has full mental capacity.

Q3) How do you proceed now?

A: KH has been deemed to have full mental capacity. He understands the risks and possible outcomes of his decision and so his wishes must be met and he should be decanulated.

On decanulation, KH has severe stridor and desaturates to 50%. He becomes very distressed and requests help.

Q4) What do you do now?

A: Once again this is now a life saving situation, the patient has requested medical help and so should be treated accordingly.

KH is sedated and re-intubated. An ENT examination shows some laryngeal oedema and granulation tissue at the tracheostomy site. He is started on steroids and ventilated for few more days until the weaning process is started again.

Q5) With regards to DoLS what do you do now?

A: KH no longer has capacity and is 'restricted' due to the use of sedation. He is under continuous control and supervision and is unable to leave. He has previously expressed wishes to have the tracheostomy removed but it is keeping him alive. He fulfils the criteria of the acid test and DoLS application should be made.

KH was finally assessed to have temporary loss of capacity due to the use of sedatives and DoLS authorisation was applied for. However, he recovered rapidly, was more compliant and able to be decanulated and sent home after a few more days of hospital stay.

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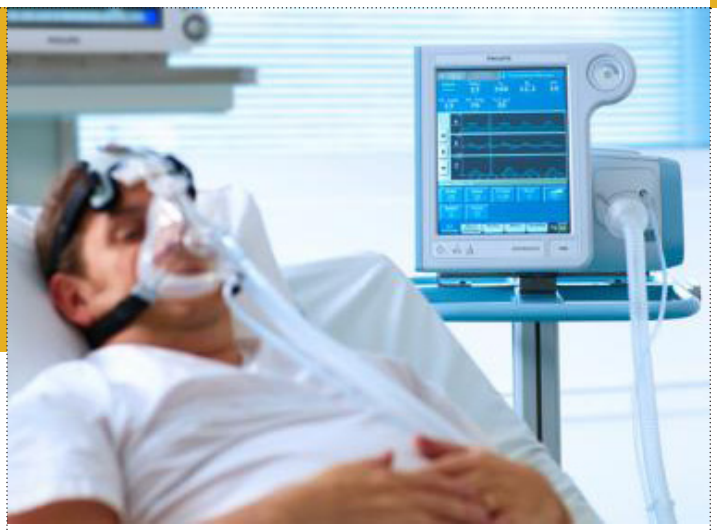
NON-INVASIVE VENTILATION: A REVIEW

N Kozman, S Bonfield, W Doherty



Non-Invasive Ventilation: A Review
Good Clinical Care

Introduction

Non-invasive ventilation (NIV), also known as non-invasive positive pressure ventilation, is a method of supporting a patient's ventilation through the use of a mask or similar device applied to the face. This differs from invasive ventilation where the respiratory system is supported by bypassing the upper respiratory tract. Despite its wide usage, its initiation and management can be a cause of trepidation for junior doctors. This article aims to better equip junior doctors to deal with NIV by providing a summary of the different types available, indications, contraindications and hints and tips for managing NIV on the wards.

Background

The concept of NIV was first described in the 1700s but it was not applied in common practice until the introduction of the "Drinker-Shaw Iron Lung" in 1928. This was a negative pressure chamber commonly used to treat respiratory failure in polio but was impractical and difficult to use. Since then, NIV has progressed significantly with most of the advancements occurring in the last 20 years (1).

NIV has been shown to be a particularly effective treatment for acute type 2 respiratory failure (T2RF) with a respiratory acidosis, particularly in chronic obstructive pulmonary disease (COPD). The use of NIV in intensive care and ward environments has been shown to reduce both the intubation and mortality rates in COPD patients with decompensated respiratory acidosis one hour after initiation of medical therapy (2). Some commonly used terms are explained in Figures 1 and 2 (3-6).

Respiratory Failure

- Failure of gas exchange as measured by arterial blood gas tensions.
  - Type 1 - PaO_2 <8kPa and $PaCO_2$ ≤6 kPa.
    - Caused by ventilation perfusion mismatch.
    - Secondary to pneumonia, pulmonary oedema, acute respiratory distress syndrome.
  - Type 2 - PaO_2 <8kPa and $PaCO_2$ ≥6 kPa.
    - Caused by alveolar hypoventilation with or without ventilation-perfusion mismatch.
    - Secondary to COPD, thoracic wall diseases and neuromuscular diseases.

Fraction of Inspired Oxygen (FiO_2)

- Percentage of oxygen inhaled, i.e. 100% O_2 = FiO_2 1.0, room air = FiO_2 0.21.
- Increasing FiO_2 will help oxygenation.

Factors Affecting Oxygenation

- Adjusting FiO_2
- Mean airway pressure (which is influenced by adjusting PEEP - see Figure 2)

Factors Affecting CO_2

- Elimination of CO_2 is dependent on minute volume (MV)
- MV = (tidal volume) x (respiratory rate)
- Tidal volume and respiratory rate can both be assisted.

Figure 1: Explanation of terms relating to respiratory failure.

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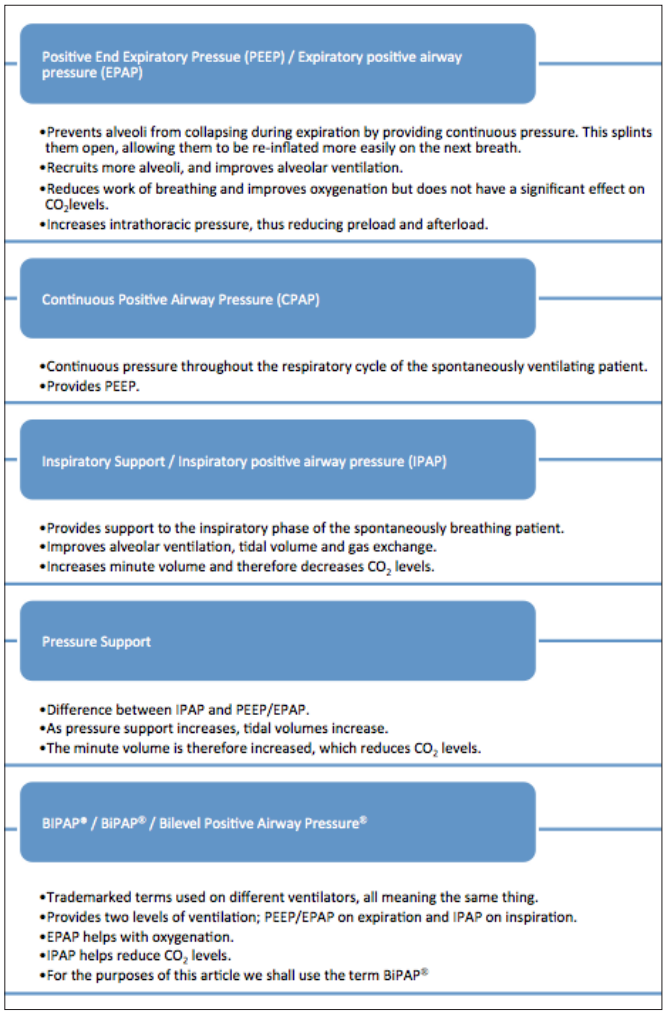

Figure 2: Explanation of terms used in NIV

Indications

The most common clinical indications for NIV include acute exacerbations of COPD where a respiratory acidosis (pH <7.35, $PaCO_2$ ≥6kPa) persists despite 60 minutes of optimal medical therapy including:

Controlled oxygen

Nebulised bronchodilators

Steroids

Antibiotics where indicated

Acute cardiogenic pulmonary oedema

Acute respiratory failure in the immunocompromised patient (2).

Other common uses for acute NIV include (4,7–10):

Hypoxaemia associated with a high respiratory rate, effort or FiO_2

Hypercapnia in a fatiguing patient

As a method to assist weaning from invasive ventilation

To help reduce the work of breathing

In type 2 respiratory failure

There is a good body of evidence stating that NIV in COPD reduces both intubation and mortality compared to standard therapy (11–14), when it is started within an hour of optimal medical treatment being initiated. There may also be a role for NIV in patients with severe respiratory acidosis (pH <7.25) and hypercarbic coma which was previously contra-indicated(2,12). Outcomes are worse if there is a coexisting metabolic acidosis (15).

NIV in asthma remains a contentious area and the decision to start it should only come from an experienced clinician. This is because acute severe asthma can result in diaphragmatic fatigue which will require invasive ventilation in the presence of hypercapnoea (12). The use of NIV as a stop-gap should not delay intubation in this circumstance.

There are also increasing numbers of patients presenting to critical care services with acute-on-chronic T2RF secondary to obesity-associated hypoventilation and obstructive sleep apnoea. In these patients, NIV is helpful in the acute setting as well as long-term, post-discharge. NIV may also be helpful in these patients in the post-operative period due to the associated complications of anaesthesia (16). Furthermore, NIV has also been shown to improve the quality of life and symptoms (such as breathlessness) in patients with advanced neuromuscular disorders.

In type 1 respiratory failure

The evidence for NIV in type 1 respiratory failure (T1RF) is less robust than in T2RF. In cardiogenic pulmonary oedema, it can improve symptoms such as dyspnoea. This is because CPAP reduces both preload and afterload, improves oxygenation and reduces the work of breathing. NIV also reduces mortality in patients with T1RF secondary to traumatic lung contusions(12,15).

The most controversial indication for NIV remains its use in pneumonia. If there is an underlying pathology such as COPD or immunocompromise, then NIV provides benefit as it reduces the risk of ventilator-associated pneumonias related to invasive ventilation. These can be especially severe in these groups of patients (9). It has been demonstrated that NIV has a high failure rate when pneumonia is the sole cause of respiratory failure, with no other co-morbidity. In addition, there is no evidence for the use of NIV in patients with T1RF secondary to acute respiratory distress syndrome(12,15).

NON-INVASIVE VENTILATION: A REVIEW

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Patient Selection Criteria

Before starting NIV, the patient needs to be carefully assessed to determine whether or not they are suitable for this treatment. A list of inclusion and exclusion criteria is summarised in Figure 3 (2).

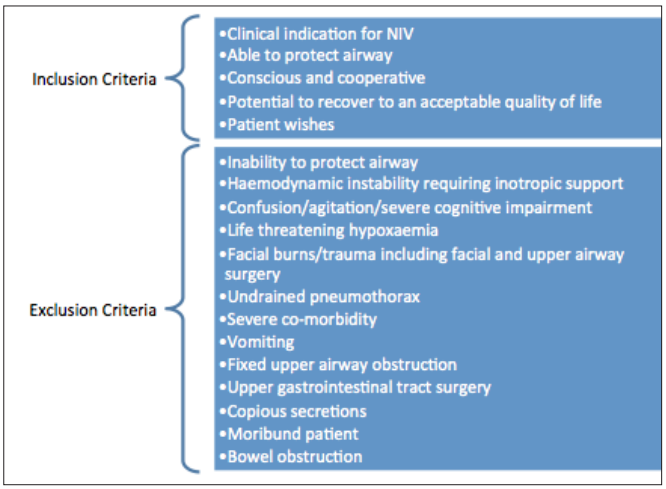

Figure 3: Patient Selection Criteria

If a patient has been deemed suitable for a trial of NIV, a ceiling of care should then be established. This should make it clear, in the event that NIV fails, whether the patient is for escalation to intubation and invasive ventilation, whether best ward care should be continued, or whether palliative care should be initiated. This decision must be made after discussion with the patient and senior clinician. It should be based on premorbid state, severity of physiological disturbance, reversibility of the acute illness and patient wishes. The decision to escalate to intensive care should be made within 4 hours of commencing medical therapy (2).

Setting Up NIV

The decision to set up NIV must be made by a doctor of ST2 level or above. Having chosen which type of NIV to use, there are a few factors to consider:

- Positioning: Sit the patient in an upright or semi-recumbent position in bed (minimum of 30°)
- Mask: Ensure this is correctly sized to the patients face
- Take care to regularly assess pressure areas, especially on the bridge of the nose. Full face masks exist to reduce the risk of pressure damage.
- Start by holding the mask or asking the patient to hold the mask to their face before strapping it on.
- If strapped to a patients face immediately, it can feel very claustrophobic and the patient is unlikely to tolerate it.
- Holding the mask will result in a leak, however, which will set the machine's alarms off. This can be equally distressing.
- Some machines have a "ramp" which increases the pressure in steps slowly, allowing the mask to be fitted to the face immediately and therefore reducing the leak.
- Do not start at the pressures that you think that the patient will need. Start at an EPAP of 4-5cm H_2O and an IPAP of 10 cm H_2O. These initial settings are tolerated by most patients.
- Both pressures can then be increased incrementally at a rate of approximately 5cmH_2O every 10 minutes. The usual pressure targeted for IPAP is 20cm H_2O but this can be limited by patient tolerance.
- Oxygen can be entrained to achieve a desired FiO_2
- Note that some machines entrain oxygen at a fixed flow rate separate to the pressures provided by the NIV ventilator. The FiO_2 is therefore not governed by the ventilator but by the mixing of air (for the pressure) and the fixed flow rate of oxygen downstream. If there is a mask leak, the machine will increase the rate of flow to the patient, to maintain the set pressure. As the flow rate of oxygen will remain the same despite the increase in total flow (required to compensate for the leak), there will be a reduction in FiO_2. It is therefore vital to ensure that the mask is well fitted as any leak can dramatically change the FiO_2. Other machines entrain oxygen through the ventilator itself and so the FiO_2 is governed by the ventilator and will remain constant despite any mask leak.
- Bronchodilators can also be administered via NIV, but often, they are better given off NIV.
- Patients should remain on the full face mask for at least 24 hours with pressure areas checked daily.
- When setting up BiPAP®, the specific mode needs to be determined:

Spontaneous

This will trigger NIV to provide support when the patient takes a breath.

Timed

This will deliver a breath irrespective of a patient's own breaths.

Timed/Spontaneous

This will trigger NIV to occur whenever the patient takes a breath but if the patient does not breathe in the desired time, it will give a timed breath (12,17).

Monitoring NIV

Monitoring is based on physiological as well as clinical parameters. Within the first 4 hours of initiating NIV, these factors should be used to form an ongoing management plan, including the likelihood of escalation to invasive ventilation.

- Baseline parameters include standard observations and arterial blood gases (ABGs).
- Continuous cardiac monitoring and pulse oximetry is mandatory for the first 12 hours.

Repeat ABGs are performed:

- 1 hour after initiation of NIV
- 1 hour after every change to the settings
- After 4 hours or earlier in patients who are not improving clinically

NON-INVASIVE VENTILATION: A REVIEW

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If acutely ill, patients need to be clinically monitored:

- Every 15 minutes for the first hour
- Every 30 minutes for the next one to four hour period
- Hourly in the following four to twelve hour period

Patient comfort and tolerance are key for ongoing compliance and factors to be assessed include:

Synchrony with ventilation

- Mask fit
- Anxiety - anxiolysis can improve tolerance
- Pressure areas (2,17)

Duration of Treatment

- If the patient has benefited from NIV in the first 4 hours, they should continue it for as long as possible in the first 24 hours.
- NIV is normally continued until the acute precipitant has passed (usually around 3 days).
- Where NIV has been successful after the first 24 hours or longer, it is appropriate to start a weaning plan (2,17).

Weaning NIV

Weaning plans are usually based around clinical improvement and patient tolerance. Normally, weaning starts during the daytime with time off the ventilator for meals, physiotherapy and other therapies. The recommended weaning plan is usually:

- Continue NIV for 16 hours on day 2
- Continue NIV for 12 hours on day 3 with 6-8 hours overnight
- Stop NIV on day 4 if able to

Often patients improve quicker than the recommended weaning plan or improve quicker than 24 hours and so weaning can occur earlier and faster (2,17).

High Flow Nasal Oxygen

Within the last five years, a new method of oxygen delivery has been developed. High flow nasal oxygen (HFNO) uses modified nasal cannulae to deliver flow rates of up to 60L/min of warmed, humidified oxygen, which are generally very well-tolerated. These high flow rates generate a moderate degree of PEEP, and oxygen can be delivered at concentrations of up to 90%(18).

Benefits of this therapy compared with standard NIV include improved patient tolerance and synchrony, by virtue of the heating and humidification of the gas; improved ability to communicate with clinical staff and family members, as there is no full face-mask; and delivery of a constant and reliable FiO_2. Humidification of oxygen reduces airway resistance, reducing work of breathing. Additionally, humidification aids mucociliary clearance, prevents atelectasis and improves ventilation-perfusion matching. This can be particularly useful in patients with COPD, in whom excessive secretions can be problematic(18).

As a developing therapy, however, the evidence base for HFNO is evolving. Small numbers of randomised controlled trials have so far been published to support its use in specific circumstances, although a large number of trials are underway. Much of the strong evidence for HFNO relates to its use in children (19). Nevertheless, it is increasingly being used in adults in the critical care setting as an alternative to NIV (20).

Due to the increased tolerability and the improvement in communication the lack of a face-mask provides, HFNO is likely to prove a useful treatment modality for patients in whom intubation would not be appropriate. In addition, evidence is emerging to support its use in optimising pre-oxygenation prior to intubation, as a method of weaning from invasive ventilation, and in the post-operative setting (21). A recent study has demonstrated increased benefit from HFNO compared to NIV in T1RF, in terms of reduced mortality in ITU and at 90 days, but found that neither reduce intubation rates in this patient group (20).

Summary

NIV is a commonly used therapy in ward and high dependency care environments. Understanding the reasons for using NIV and the theory behind it will allow junior doctors to more easily deal with these patients who are often very unwell. This will allow optimal ongoing care of these patients even if NIV is unsuccessful.

Questions

1. A 68 year-old man with a 5-year history of COPD is admitted on the acute medical take. He has been unwell with progressive shortness of breath, wheeze and cough productive of copious purulent sputum for 6 days. He is diagnosed with an infective exacerbation of COPD and medical management commenced.

His ABG shows he is in T2RF and he is started on BiPAP® with an IPAP of 18 and PEEP 6.

His initial ABG showed:

pH: 7.29
PaO_2: 6.8 kPa
$PaCO_2$: 7.2 kPa
Bicarbonate: 20

His repeat ABG in one hour shows:

pH: 7.27
PaO_2: 7.4
$PaCO_2$: 8.5
Bicarbonate: 19

NON-INVASIVE VENTILATION: A REVIEW

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What is the most appropriate option regarding his BiPAP® settings:

a) Increase the PEEP only
b) Increase the FiO2 only
c) Increase the IPAP and PEEP by the same increment
d) Increase the IPAP but keep the PEEP the same
e) Increase the IPAP but keep the PEEP the same but also increase the FiO_2

2. Which of the below is an absolute contra-indication to NIV?

a) Nausea and vomiting
b) Agitation
c) Cardiac ischaemia
d) Haemodynamic instability
e) Inability to protect own airway

3. With respect to PEEP which is correct?

a) It helps with removal of CO_2
b) It depends on the FiO_2
c) It helps improve oxygenation by recruitment of more alveoli
d) It helps improve oxygenation by increasing the minute volume
e) It allows the alveoli to collapse back down to atmospheric pressure on expiration

4. An 80 year-old man with a history of congestive cardiac failure presents with evidence of acute pulmonary oedema. He is started on the correct medical management. His ABG demonstrates:

pH: 7.29
PaO_2: 6.4
$PaCO_2$: 3.2
Bicarbonate: 18

With regards to his management which is correct:

a) Continue with current management as he is not in T1RF
b) Start CPAP
c) Start BiPAP® at an IPAP of 10cm and EPAP of 5 cm H_2O
d) Start BiPAP® at an IPAP of 20cm and EPAP of 5 cm H_2O
e) Give controlled oxygen aiming for SpO_2 of 88-92%

5. When reviewing a patient on NIV, which of the following should be reviewed:

a) Tolerance to NIV
b) Synchronicity to the machine
c) Pressure areas and mask fit
d) Response to the treatment (via arterial blood gas tensions)
e) All of the above

Answers

Answer to Question 1

This gentleman is not on optimal BiPAP® settings yet and his ABG is continuing to deteriorate. His $PaCO_2$ is continuing to climb despite therapy. CO_2 is governed by tidal volume which is increased by increasing the pressure difference. Therefore d or e are correct. He remains hypoxic however on his current settings. Oxygenation can be improved by increasing the PEEP (which would require an even greater rise in IPAP to ensure increasing pressure difference but may impact on tolerance of NIV) or, the second, increase his FiO_2. Therefore option E is correct.

Answer to Question 2

An inability to protect one's own airway acts as an absolute contra-indication to NIV. In these situations, if appropriate, the patient should be referred for invasive ventilation. All of the other options listed are relative contra-indications and should be considered prior to commencement of NIV. Option E is therefore correct.

Answer to Question 3

PEEP helps to improve oxygenation by recruiting more alveoli into gas exchange by preventing them from collapsing down to atmospheric pressure making them more easily reinflated. This results in more alveoli in gas exchange and improves alveolar ventilation and as such improves oxygenation. Option C is correct therefore.

Answer to Question 4

This gentleman is in acute pulmonary oedema and acute T1RF. In these situations CPAP provides benefit as it improves oxygenation but also lowers preload and afterload by increasing intra-thoracic pressure. This should help improve the symptoms of pulmonary oedema. There is no need for BiPAP® at present as he is not in T2RF. Therefore option B is correct.

Answer to Question 5

The answer is option E, all of the above. When reviewing a patient on NIV, a full A-E assessment should be undertaken taking time to particularly look at patient tolerance, synchronicity with the machine, pressure areas, mask fit and leak as well as assessing the clinical effectiveness of the treatment.

NON-INVASIVE VENTILATION: A REVIEW

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PERI-OPERATIVE CARE OF PATIENTS UNDERGOING EMERGENCY SURGERY

AJ Burton, GV Hasselt

Peri-operative care of patients undergoing Emergency Surgery
Good Clinical Care

Abstract

Death rates associated with emergency surgery are high. Around 80% of all reported surgical deaths are attributable to those who have undergone emergency surgery. As this patient population makes up nearly 50% of all surgical teams' workloads it is essential that those caring for them know how to identify, assess and treat these patients without delay. Risk stratification tools including the P-POSSUM score should be used to help identify at risk patients. Preoperative optimisaiton of these patients is essential and failure to do so in a time critical manor directly increases their post-operative morbidity and mortality.

This process should involve, amongst other things, treating hypovolaemia using goal directed fluid therapy, the early diagnosis and treatment of underlying/concurrent sepsis, adequate analgesia, optimisation of patients' respiratory function and VTE risk assessment. Post operatively it is imperative that these patients are cared for in the correct setting, a decision that should be made preoperatively where possible. All those with a predicted mortality score > 5% should be considered for ICU admission. Physiological tracker and trigger systems such as the 'National Early Warning Score' (NEWS) should be used for all patients post-operatively to help identify deteriorating patients. Rates of post-operative complications are high in these patients.

Specialist care should be sought in a timely manor in any such patients to prevent delays in their treatment thus minimising their morbidity and mortality. Completion of audit tools such as the National Emergency Laparotomy Audit (NELA) will improve the quality of care patients receive.

Peri-operative care of patients undergoing Emergency Surgery

Surgical operations are commonly classified into one of four groups as defined by the 'National Confidential Enquiry into Patient Outcome and Death' (NCEPOD) based upon their degree of urgency (See Table 1.0). 'Emergency' (within one hour) and 'Urgent' cases (as soon as possible, usually within twenty-four hours) are classed as 'non-elective' cases. (1) This article will focus on the peri-operative assessment and treatment of these patients. The way in which these patients are managed has a significant bearing on their outcomes.

Classification	Definition
Elective	Intervention planned or booked in advance of routine admission to hospital. Timing to suit patient, hospital and staff.
Expedited	Patient requiring early treatment where the condition is not an immediate threat to life, limb or organ survival. Normally within days of the decision to operate.
Urgent	Intervention for acute onset or clinical deterioration of potentially life-threatening conditions, for those conditions that may threaten the survival of the limb or organ, for fixation of many fractures and for relief of pain or other distressing symptoms. Normally within hours of the decision to operate.
Immediate	Immediate life, limb or organ-saving intervention – resuscitation simultaneous with intervention. Normally within minutes of the decision to operate.

Table 1

Non-elective operations account for nearly 16% of the surgical workload in NHS hospitals. (2) The Royal College of Surgeons estimates that in total, the extended care provided to these patients represents 40-50% of surgical teams' clinical time. (3) Many of these patients are elderly with the most common age group being 70-80 years old and most have multiple comorbidities. (2) As a result morbidity and mortality rates in emergency surgery are high; as many as 50% of patients will experience complications related to their surgery and deaths associated with emergency surgery account for 80% of all reported surgical deaths. General surgical patients account for the largest proportion of emergency surgical cases and have an associated mortality of 25%; they also account for 14,000 admissions to ITU every year (3, 4).

Non-elective surgical cases are likely to be encountered by trainees on a frequent basis. Trainees should understand how best to approach these patients, to avoid harm and help reduce the burden on NHS resources.

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The biggest risk to these patients is delaying their treatment. Recent research has shown that 20% of non-elective patients failed to receive timely surgery. (5) These delays increase the risk of complications and increase mortality rates as well as the cost to the NHS. (3,4,6) It is therefore imperative that this cohort of patients is diagnosed promptly and that high-risk patients are identified, their physiology optimised and their treatment implemented promptly. Post-operatively the ongoing care of these patients must also be appropriate to their needs.

1. Timely diagnosis:

The key to ensuring a timely diagnosis is the ability to take a focused and detailed history and examination, supported by the use of appropriate investigations and early specialist senior help. The patient's requirement for surgery then needs to be determined as per the NCEPOD classification. It is not possible to assign all diagnoses to one of the four groups mentioned earlier, as most pathologies can present with varying levels of urgency.

However, the following table provides examples of operations that could be classified under each of the four different groups. In practice, determining the urgency of an operation will rely on the primary pathology and the patient's clinical condition, as well as the opinion of an experienced registrar or consultant.

Code	Category	Expected lLcation	Example Scenarios
1	*Immediate*	*Next available operating theatre – existing lists if required*	*· Ruptured aortic aneurysm · Major trauma to abdomen · Fracture with major neurovascular deficit · Compartment syndrome*
2	*Urgent*	*Day time 'emergency list' or Out-of-hours emergency theatre (including at night)*	*· Compound fracture · Perforated bowel with peritonitis · Critical organ or limb ischaemia · Perforating eye injury*
3	*Expedited*	*Elective list that has spare capacity or day time emergency list*	*· Tendon and nerve injuries · Stable and non septic patients for a wide range of procedures · Retinal detachment*
4	*Elective*	*Elective theatre list, booked and planned prior to admission*	*· Elective AAA · Laproscopic cholecystectomy · Varicose vein surgery · Joint replacements*

Table 2: NCEPOD Classification of Intervention (1)

2. High risk patients:

Studies have shown that 'high-risk patients' account for over 80% of post-operative deaths despite their surgery accounting for less than 15% of all in-patient procedures. (7,8) Risk factors such as advanced age, existing co-morbidities and requiring major or urgent surgery are associated with significantly increased risk.

To help in the identification and assessment of high-risk patients several risk stratification tools have been introduced which standardise this process and are now an integral part of clinical practice. The two most commonly used are the Portsmouth Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity (P-POSSUM) and the Surgical Risk Scale (SRS). (9) The P-POSSUM score is explained below.

P-POSSUM Score

The P-POSSUM score is the most validated risk stratification tool and is designed to help inform patients and clinicians of the likely morbidity and mortality risk that surgery poses. It is an adaptation of the POSSUM score and aims to reduce the POSSUM score's tendency to over predict death in patients. It comprises of 12 physiological and 6 operative parameters (see Table 3 below), which are scored 1,2,4 or 8 depending on their severity. The greater the physiological and operative scores the higher the predicted morbidity and mortality. (10)

Physiological Parameters				
Criteria/ Score	*Score 1*	*Score 2*	*Score 4*	*Score 8*
Age (years)	*<61*	*61-70*	*>70*	
Cardiac	*No cardiac failure*	*Diuretic, Digoxin, antihyper-tensives or anti-anginals treatment*	*Peripheral oedema, warfarin, cardiomy-opathy*	*Raised JVP, Cardio-megaly*
Respiratory	*No dys-pnoea*	*Dyspnoea on exertion*	*Limiting Dyspnoea*	*Dyspnoea at rest, pulmo-nary fibrosis or consolida-tion on CXR*
ECG	*Normal*		*AF, rate 60-90*	*Any other abnormality*
Systolic BP (mmHg)	*110-130*	*100-109 131-170*	*>170 90-99*	*<90*
Pulse	*50-80*	*40-49 81-100*	*101-120*	*<40 >120*
Haemoglobin (g/l)	*130-160*	*115-129 161-170*	*100-114 171-180*	*<100 >180*
WCC ($x10^9$/ml)	*4-10*	*10.1-20 3.1-4*	*>20 <3*	

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Urea	*<7.6*	*7.6-10*	*10.1-15*	*>15*
Sodium (mmol/l)	*>135*	*131-135*	*126-130*	*<126*
Potassium (mmol/l)	*3.5-5*	*3.2-3.4 5.1-5.3*	*2.9-3.1 5.4-5.9*	*<2.9 >5.9*
GCS	*15*	*12-14*	*9-11*	*<9*
Operative Parameters				
Operative Severity	*Minor*	*Moderate*	*Major*	*Complex*
Number of Procedures	*1*		*2*	*>2*
Blood Loss	*<100ml*	*101-500ml*	*501-999ml*	*1000+ml*
Contamination	*No Soiling*	*Minor Soiling*	*Local Pus*	*Pus, blood or free bowel contents*
Malignancy	*Not malignant*	*Primary malignancy only*	*Malignancy with nodal metastasis*	*Malignancy with distant metastasis*
CEPOD Criteria	*Elective*		*Urgent*	*Immediate*

Table 3: Physiological and Operative parameters of the P-POSSUM Score (10)

Patients are divided into three groups based on their scores, 0-5% low risk, 5-10% medium risk and >10% high risk. Patients should be managed depending on their level of risk.

Those patients with a 5-10% risk of mortality should have the following: (4, 11)

- Two hourly observations (as a minimum)
- The consultant responsible for the patient informed
- Referral to critical care considered
- An arterial line, oesophageal doppler and central line considered (in theatre)

Those with a >10% risk of mortality should have:

- A consultant surgeon operating
- Referral to critical care
- Intra operative cardiac monitoring
- Central line
- Admission to ITU post operatively.

Each patient's predicted risk of morbidity and mortality should be discussed with them and documented on the consent form in accordance with GMC guidance before emergency surgery is undertaken. (12). In some cases the P-POSSUM score will help identify patients whose risk from surgery is so great that surgery may not be suitable. This is a decision that should only be made by experienced senior clinicians.

3. Patient optimisation:

The time to optimise a patient before emergency surgery is often quite short but vitally important and should not be delayed. (4, 13) It is widely agreed that pre-existing co-morbidities (present in 90% of high risk surgical patients) and patients being acutely unwell on admission are major contributing factors to raised mortality rates. (5, 13, 14) Pre-operative optimisation aims to address the risk these pose to patients in order to reduce their mortality and morbidity.

Research has shown that particular areas to focus on during patient optimisation include fluid assessment, identification and treatment of sepsis, patient analgesia, maximising respiratory function and assessment of venous thromboembolism (VTE) risk. (4, 5)

Fluid assessment

Correct fluid resuscitation of emergency surgical patients is vitally important. A 2011 NCEPOD report demonstrated that 53% of patients whose fluid management was considered substandard died within 30 days of their operation; 20% from inadequate fluid and 33% from excessive fluid. (4) Clinical markers suggestive of hypovolaemia include a heart rate > 100 beats.min-1, systolic blood pressure < 100mmHg, cool peripheries, absent JVP waveform, dry mucous membranes, central capillary time > 2 seconds and urine output <0.5ml/kg (ideal body weight)/hr.

If patients are hypovolaemic, wide bore access (16-20G) should be obtained and goal directed fluid therapy should be initiated. Measured aliquots of crystalloid (250-500mls depending on the size of the patient and their co-morbidities) should be administered rapidly and changes to the clinical signs above should be assessed after each one.

Fluid boluses should be discontinued once the patient is no longer fluid responsive (the signs and symptoms of hypovolaemia have corrected) or signs of raised extravascular fluid develop. (15) If patients do not improve after 20mls/kg then urgent senior help should be sought as this could represent septic shock, which has an associated mortality of up to 25%. (16)

Sepsis

Sepsis is defined as the presence of a systemic inflammatory response syndrome (SIRS) with a confirmed or suspected source of infection. (16)

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Sign / Symptom	Measurement
Heart Rate	*> 90 beats per minute*
Temperature	*<36˚C / > 38˚C*
White cell count	*< 4,000/ul / > 12,000/ul*
Respiratory rate	*> 20 breaths per minute*

Table 4

Sepsis is the leading cause of prolonged critical care admission and death in patients undergoing emergency surgery. The treatment of sepsis is time critical. (4) Once diagnosed, initial treatment is centred around the 'Sepsis Six', a treatment bundle derived from the 'Surviving Sepsis Campaign'. The 'Sepsis Six' consists of three diagnostic and three therapeutic steps.

The diagnostic steps include taking blood cultures (preferably two sets and prior to antibiotics as long as it does not delay their administration), measuring serum lactate (>4 suggests severe sepsis) and measuring urine output (aim for > 0.5ml/kg of ideal body weight/hr).

The three therapeutic steps involve delivering high-flow oxygen (15L per minute through a non-rebreathing mask), administering empirical intravenous antibiotics (according to local hospital guidelines) and commencing intravenous fluid based on the assessment of the patient's fluid status. These steps should be implemented as soon as possible and within one hour of making the diagnosis. Successful implementation of this bundle has been shown to decrease both patient mortality and length of hospital stay. (16, 17)

Patient Analgesia

Assessment of the adequacy of patients' analgesia is one of the key pre-operative standards outlined by the 'Standards for Unscheduled Surgical Care' document. (3) There are significant physiological advantages of treating pain appropriately, including reduction in sympathetic activity, acute coronary syndromes, tachyarrhythmias, respiratory complications and thrombotic events. Good analgesia also improves patients' mobilisation and facilitates earlier hospital discharge. (14, 18)

Treatment of pain should follow the 'WHO analgesic ladder' where possible. However, most patients awaiting non-elective surgery will be nil-by-mouth, therefore treatment with intravenous options including paracetamol and morphine is often needed. All patients in pain and not imminently going to theatre should be referred to the 'Pain Team', if available, for expert advice, as many of these patients will be elderly with co-morbidities that could significantly alter the way they respond to analgesia.

Respiratory Function

The importance of ensuring adequate oxygen delivery prior to major surgery has been well highlighted and unless contra-indicated patients' pre-operative oxygen saturations should be >95%. (19) Patients with premorbid respiratory disease have an associated 30-day mortality of 3.7%. If supplementary oxygen is required, a cause should be sought and referral to the respiratory clinicians and physiotherapists should be considered.

Respiratory complications are also the most common post-operative complication and occur in nearly 10% of patients undergoing emergency surgery. (4) It is important to remain vigilant for signs of declining respiratory function post operatively and to respond in a timely manner.

VTE Prophylaxis

All patients should have their VTE risk assessment completed on admission to hospital. Patients undergoing emergency surgery are often elderly and likely to be high risk for VTE. The risk of pulmonary embolism without VTE prophylaxis in this cohort of patients is thought to be around 5%. Some patients may already be taking anticoagulants or antiplatelet therapy. Thus when considering VTE risk both the risk of bleeding and VTE risk must be taken into account and balanced. (20)

Risk factors for VTE include

- *Cumulative anaesthetic and surgical time greater than 90 minutes or 60 minutes if pelvic or lower limb surgery*
- *Age >60 years old*
- *Active cancer*
- *Dehydration*
- *Critical care admission*
- *Known thrombophilias*
- *BMI > 30kg/m^2*
- *One or more significant co-morbidities*
- *Personal history or first-degree relative with history of VTE*
- *Use of hormone replacement therapy*
- *Use of oestrogen-containing contraceptive therapy*
- *Varicose veins with phlebitis.*

The need for pharmacological VTE prophylaxis must be weighed against the risk of bleeding.

Risk factors for bleeding include

- *Active bleeding*
- *Acquired bleeding disorders*
- *Concurrent use of anticoagulants*
- *Central neural axial blockade expected within the next 12 hours*
- *Acute stroke*
- *Thrombocytopenia – platelets < 75 x 10^9/l*
- *Untreated inherited bleeding disorders*

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A patient's VTE prophylaxis should comprise of mechanical and pharmacological components. Mechanical prophylaxis includes anti-embolic stockings and intermittent pneumatic compression devices. Pharmacological prophylaxis is normally heparin based but will depend upon local policy and individual patient factors such as renal function and BMI. (21) The 2009 NCEPOD report into the care of patients who died within four days of admission revealed that only 52% of surgical patients received VTE prophylaxis. (20) All patients, especially emergency surgical patients, should have their VTE risk reassessed during their admission as it will often change. (21)

The National Institute of Academic Anaesthesia's Health Service Research Centre is currently conducting the 'National Emergency Laparotomy Audit' (NELA). This is a nation wide research project that aims to collect data on patients undergoing an emergency laparotomy with the primary goal of improving the quality of care for these patients. (22) It is important that trainees ensure that this audit information is collected for such patients to help to improve the future care of this patient cohort.

4. Post operative care

The immediate aims of post-operative care for emergency surgical patients are similar to those during the pre-operative stage, with the focus being on the optimisation of physiological parameters (see above). However, there are several other important factors to consider including the most suitable location for their post-operative care, recognising the 'deteriorating patient' and involving specialist help early.

Suitable location for post-operative care

The decision as to where patients are best managed following emergency surgery should be made preoperatively based on the patient's presenting complaint and their risk stratification score. (3) Sometimes this score can change if intraoperative findings vary from those predicted preoperatively. If this is the case patients' surgical parameters should be recalculated following surgery, to aid the decision as to where the patient needs to be looked after post-operatively.

Failure to send patients to the appropriate level of post-operative care is known to result in avoidable complications leading in some cases to death. (20, 23) All patients with a P-POSSUM mortality risk of >5% should be admitted to critical care in the immediate postoperative stage. (4) This decision should be made by the patient's named surgeon and the admitting ITU clinician.

Equally important is the decision as to when a patient is suitable for discharge from ITU to the ward. Premature discharge from critical care has been identified as an important risk factor for post-operative death. (23) This should be a decision made by the lead clinician for ITU and the patient's named consultant. Patient transfers from ITU to the ward should ideally only occur between 07:00 – 22:00 to reduce the risk to patients. (24)

Recognising 'the deteriorating patient'

All post operative patients including those discharged from ITU should have a clearly documented plan regarding the frequency with which observations should be done as per NICE guidelines. It is recommended that all hospitals use physiological tracker and trigger systems with a graded response to monitor their patients to ensure timely reviews by suitably trained staff. (24) The most commonly used system is the 'National Early Warning Score' (NEWS).

This involves measuring six physiological bedside parameters: respiratory rate, oxygen saturations, temperature, systolic blood pressure, pulse rate and level of consciousness. Each parameter is scored depending on its proximity to normality; this categorises patients into low, medium, high score groups that dictate the response required and the frequency with which future observations should occur. (25) Unfortunately this is still not implemented nationally, with 12% of hospitals not currently using such a system. (5)

Involving Specialist Care

Prompt intervention is fundamental to the successful treatment of the patient who deteriorates after surgery. (4) This underlines the importance of trainees calling for help when needed. In cases reported to NCEPOD where patients ultimately died, 21% of trainees did not call for help. (4) This help can be in the form of a senior member of the team, the medical registrar, critical out reach nurses or intensive care.

Even before patients deteriorate, high-risk patients (e.g. the elderly) should be referred for specialist review to help optimise their condition and comorbidities. The 'Standards for Unscheduled Surgical Care' report states that all elderly patients admitted with hip fractures should be reviewed by a geriatrician within 72 hours of admission and that postoperative care should involve a geriatrician-directed multi-professional rehabilitation team. (3) Currently only 30% of elderly patients who undergo an emergency laparotomy have input from a geriatric specialist demonstrating that there is still significant room for improvement within this area. (26)

Conclusion

Patients undergoing emergency surgery face high levels of morbidity and mortality. (3,4) To reduce this risk, patients must be identified and their treatment implemented in a timely manner whilst minimising any delays to surgical treatment. Peri-operative optimisation has been shown to reduce long-term morbidity and mortality and must be continued into the postoperative phase. (5) These approaches to non-elective surgical patients will help to improve outcome and further improve the care we provide to our patients.

PERI-OPERATIVE CARE OF PATIENTS UNDERGOING EMERGENCY SURGERY

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MECHANISM OF ACTION, MONITORING & REVERSAL OF NEUROMUSCULAR BLOCKING AGENTS - THE USE OF SUGAMMADEX

T Jacobs, MV Copp

Mechanism of action, monitoring & reversal of neuromuscular blocking agents - the use of Sugammadex
Teaching & Training

Abstract

The classical triad of anaesthesia consists of hypnosis, analgesia and muscle relaxation. The introduction of neuromuscular blocking drugs (NMB) in the 1940's transformed the way in which anaesthesia could be safely delivered to patients. The NMB drugs provided the ability to paralyze patients to facilitate intubation of the trachea and provide muscle relaxation during major surgery.

The NMB drugs work by occupying nicotinic Acetylcholine receptors (nAchR) in a competitive antagonism with endogenous acetylcholine (Ach) at the neuromuscular junction. At the end of surgery muscle paralysis usually needs to be reversed by the administration of anticholinesterase drugs such as Neostigmine. These drugs have known side effects which can give rise to problems in some patients.

A new novel drug called Sugammadex has been introduced into anaesthetic clinical practice which has a completely different mechanism of action to reverse NMB drugs. It brings significant safety benefits for some patients. Its drawback is that it is expensive. In this article we will overview the role and mechanism of action of NMB drugs, including reversal, and will highlight some specific indications for Sugammadex.

Mechanism of action, monitoring & reversal of neuromuscular blocking agents - the use of Sugammadex

Learning Points

- *Mechanism of action of neuromuscular blocking drugs*
- *Monitoring of depth of neuromuscular blocking drugs*
- *Reversal of neuromuscular blocking drugs*
- *Problems occurring with inadequate reversal*
- *Overview of Sugammadex as a novel reversal agent*

Introduction

General anaesthesia is a classical triad of hypnosis, analgesia and muscle relaxation. The majority of general anaesthetics today are given by using the Laryngeal Mask Airway or other supraglottic device to deliver anaesthesia and do not require administration of a neuromuscular blocking drug. Major surgery involving opening of the abdomen or chest usually requires intubation of the trachea and muscle relaxation to facilitate surgical operating conditions.

The last few years have seen a large increase in laparoscopic surgery and this will also usually involve administration of an NMB drug as part of the triad of anaesthesia.

Neuromuscular Blocking Drugs

Neuromuscular blocking drugs provide the relaxation component of the classical triad of anaesthesia as shown in the figure 1. Neuromuscular blocking drugs are classified into depolarising and non-depolarising neuromuscular blocking drugs. In this article we shall be considering non-depolarising blocking drugs of the quaternary ammonium structure namely Rocuronium and Vecuronium. The other type of non-deolarising blocker, Benzylisoquinoliniums (e.g. Atracurium) are not effected by Sugammadex.

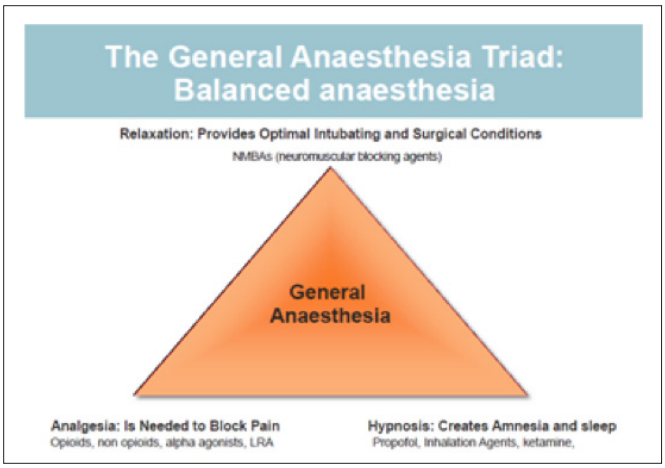

Figure 1: The triad of anaesthesia.

The non-depolarising neuromuscular drugs were introduced into modern anaesthetic practice after first being used in 1942 to facilitate muscle relaxation during an appendicectomy. The early drugs d-Tubocurarine and Pancuronium were considered long acting and had a number of undesirable side effects.

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A significant advance was the introduction of intermediate acting NMB's Vecuronium and Atracurium in the 1980's. Rocuronium was introduced in 1994. Binding of non-depolarising NMBs to the nAchR prevents Ach gaining access to the receptor and resulting in no muscle contraction. A threshold amount of Ach is required to cause depolarisation.

The binding of the NMBs is a dynamic process, competing with Ach for the receptor. If the concentration of the Ach is increased then muscle tone will return. In normal conditions only a relatively small amount of receptor activation is required to generate a muscle contraction, therefore a large amount of NMB is required in the synapse to affect a block. Greater than 70% of the receptors have to be blocked before any weakness is evident (1). Neuromuscular block is described in terms of depression of a single muscle twitch 'height'. The height refers to a description of the distance along a vertical bar, as a fraction. I.e. full twitch (100%); half twitch (50%).

Assessment of Neuromuscular Block

The assessment of NMB, and therefore whether paralysis is wearing off, is performed as outlined below:

1) Clinically, with tests such as a sustained head lift for 5 seconds

2) With a peripheral nerve stimulator, and then watching the muscle twitch response

3) Mechanomyography or Accelomyography. The force of muscle contraction can be determined by the acceleration.

Both clinical and peripheral nerve stimulator assessment are subjective measurements of how well a patient is reversed from neuromuscular block. The interpretation of these tests is such that it is sometimes possible that the patient has a small degree of paralysis at the end of surgery that is not recognized. This small degree of paralysis may have very significant implications postoperatively for a small number of patients as discussed later on in this review

Mechanomyography and acceleromyography are both methods of objective measurement of NMB and thus much more accurate at assessing the level of block but these methods are rarely used in everyday clinical practice.

One of the more common methods, both clinically and asked about in exams, is the peripheral nerve stimulator. To stimulate a nerve a transcutaneous current is applied to a peripheral nerve (usually facial or ulnar) using ECG electrodes as in Figure 2. This supramaximal current results in all the motor nerve fibres being stimulated and then maximum muscle contraction elicited. In an ideal world the muscle contraction, or single twitch, can be compared pre and post administration of a NMB. This can guide the anaesthetist the degree of blockade. The twitch will only start to be depressed when there is about 70% of all the nAchR are blocked.

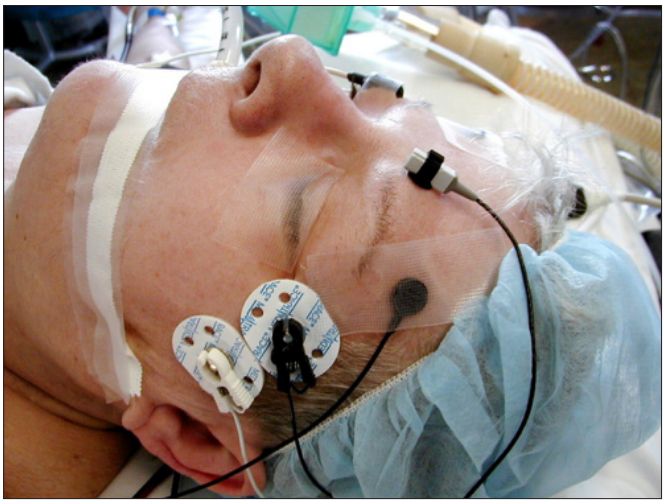

Figure 2: A Peripheral Nerve Stimulator is used to assess the degree of NMB by visual and tactile means.

In the 1970s Ali et al. described a new method of assessing block called 'The Train of Four' (TOF) (2). The aim was to avoid having to perform a pre-NMB twitch at the time of induction. The TOF is four supramaximal electrical stimuli at 0.5 second intervals. This allows the anaesthetist to compare the number of twitches elicited (the train of four count) and when four twitches are seen compare the first twitch (T1) to the fourth twitch (T4).

There is a predictable pattern of twitches with increasing neuromuscular blockade. As more muscle relaxant is given the twitches start to fade away. T4 followed by T3 down to T1. The reverse is true as the NMB wears off. The total degree of paralysis can be inferred from the ratio of the amount of twitch between T1:T4. If the twitch height of T4 is strong then, for example the TOF ratio may be 0.8 or 0.9.

The peripheral nerve stimulator can also be used to assess the depth of block by performing a measurement called the post-tetanic count (PTC). This is where a tetanic stimulus of 50 Hz is given followed by 10 to 20 single stimuli of 1Hz. The PTC allows assessment of a deep level of NMB but is rarely used by clinicians in the UK.

The TOF count and TOF ratio and the PTC are all essentially looking for the phenomenon of "fade" of the muscle twitch response after application of a tetanic stimulation. In simple terms if "fade" is present then there is NMB present at the neuromuscular junction.

In order to safely reverse NMB using conventional anticholinesterase drugs, there should be at least two twitches of a train of four count present before the reversal agent is administered. In other words reversal of neuromuscular block with conventional anticholinesterase drugs can only take place when there has been sufficient time for block to have spontaneously recovered to the level of 3 or more twitches of the TOF count.

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The aim of safe reversal of NMB is to have a patient who has adequate spontaneous breathing and the ability to maintain their own airway. The ideal reversal would be that all of the effects of the NMB are eliminated so there is no chance of residual paralysis after extubation. In clinical practice the gold standard of adequate reversal is when there is a TOF ratio (T1:T4) of 0.9 present.

Mechanism of reversal & anticholinesterase drugs

Reversal of NMBs are performed by increasing the amount of Ach at the neuromuscular junction by administering an anticholinesterase drug such that the NMB is displaced from the nAchRs by the presence of increased Ach. The remaining NMB is still present until is diffuses away from the neuromuscular junction (NMJ) or is metabolised.

The reversal most commonly used at present is Neostigmine. This is an acetylcholinesterase inhibitor, or by another name an anticholinesterase for ease of language. By blocking the breakdown of Ach there is more of it around in the NMJ and therefore can compete with the NMB at its binding site allowing muscle strength to return.

The anticholinesterase drugs act by stimulating the parasympathetic nervous system (PNS) (i.e. both the nicotinic receptors at the NMJ and the muscarinic receptors in the autonomic ganglia of the PNS). This parasympathetic stimulation has an effect in all systems of the body and, unfortunately, not just limited to the NMJ. It is therefore necessary to give an antimuscarinic agent to reduce side effects such as bradycardia and bronchospasm that may occur. Classically Neostigmine is used in combination with Glycopyrrolate in the doses of 2.5mg Neostigmine to 0.5mg Glycopyrrolate. The dose of neostigmine used for reversal of NMB is 50 µg/kg.

The aim of successful and complete reversal is to have a patient who has no clinical muscle weakness at the end of surgery. If NMB is inadequately reversed patients can experienced the effects of Post-Operative Residual Curarisation (PORC).

Post-operative Residual Curarisation

Post-operative residual curarisation (PORC) is defined as a TOF ratio of <0.9. It is thought to be a preventable patient safety issue. Naguib et al. showed that the PORC rate for intermediate NMB drugs, such as Rocuronium or Atracurium was up to 0.35. (3)

Residual paralysis has been shown to be detrimental to patient recovery. Murphy et al (4) highlighted that residual neuromuscular block is a risk factor for:

- *Increased acute respiratory events in recovery (hypoxaemia and airway obstruction)*
- *Unpleasant symptoms of muscle weakness*
- *Longer stay in recovery*
- *Increased risk of postoperative pulmonary complications*

Symptoms of PORC are usually a general feeling of weakness, double vision, difficulty in generating cough and the ability to clear the throat. Often these are missed when patients are in the recovery room after surgery and the symptoms will resolve spontaneously over time. Occasionally the effects can be much more serious and give rise to critical respiratory events that require intervention in order to prevent harm coming to the patient.

There is now a new drug called Sugammadex that can be used to reverse NMB. It can eliminate the potential for PORC in patients and provide complete reversal from NMB.

Sugammadex

Sugammadex is a drug that became available for use in 2008. A scientist called Dr Anton Bom discovered and modified it for use to reverse neuromuscular block 5. The drug is classified as a cyclodextrin meaning it has a simple sugar ring structure.

Sugammadex has revolutionized the anaesthetic management of reversal of neuromuscular block (NMB) by way of its unique mechanism of action. It encapsulates the aminosteroid neuromuscular blocking drugs rocuronium and vecuronium. Sugammadex does not encapsulate the benzylisoquinolonium NMBs, ie Atracurium. Figure 3 and 4.

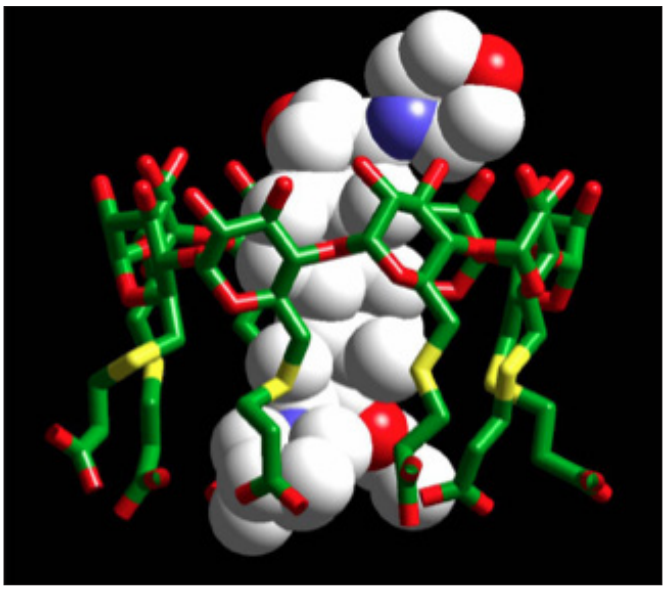

Figure 3. The cyclodextrin ring of Sugammadex encapsulates the aminosteroid NMB drugs Rocuronium and Vecuronium.

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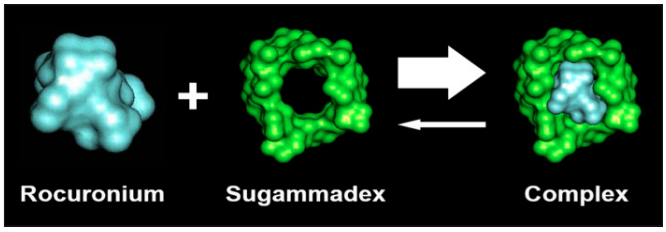

Figure 4. Sugammdex has a very high affinity for the amino steroid NMB drugs Rocuronium and Vecuronium. The affinity is such that once the Rocuronium and Sugammadex complex is formed it will not separate.

The major difference between Sugammadex and the conventional reversal drug neostigmine is that because the Rocuronium is completely removed from the neuromuscular junction it can produce complete recovery of neuromuscular function. This means that PORC can be completely avoided which brings significant safety benefits for patients.

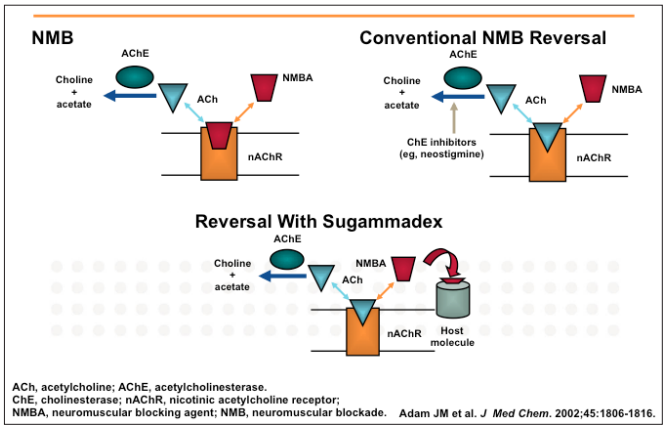

Figure 5: Mechanism of reversal and anticholinesterase drugs.

A major benefit is that Sugammadex can predictably reverse the effects of NMB drugs from any level of block whereas with conventional reversal the TOF count needs to return to 2 twitches before reversal can be safely attempted. The ability to reverse from any depth of neuromuscular block has given the anaesthetist the possibility of maintaining a deeper level of NMB right up to the end of surgery which can bring significant benefits to some patients where surgical operating conditions can be optimized using the triad of anaesthesia right up to the end of surgery. (6)

Another benefit of Sugammadex is that by not giving Neostigmine and Glycopyrrolate the undesirable effects of the antimuscarinic agents, which may be detrimental to certain patient populations, are also avoided.

Why has Sugammadex not universally replaced neostigmine in clinical practice? Quite simply the cost of the drug makes this prohibitive. Clinicians recognize the benefits of using Sugammadex for reversal of neuromuscular block but are selective in the cases where they use it to ensure the correct patient groups can benefit from it without bringing about a detrimental effect on the healthcare budget.

Sugammadex is a significant advance in the management of neuromuscular block in modern day anaesthesia.

Specific uses for Sugammadex in clinical practice

As mentioned previously Sugammadex is not used routinely at present in clinical anaesthesia. However, in some instances its use is becoming very prevalent. Sugammadex is most often used when there is increased risk of respiratory compromise post surgery, such as thoracic or bariatric surgery. This patient population is at increased risk of hypoxia, atelectasis and, in the case of bariatric surgery, obstructive sleep apnoea. Full reversal of NMB, with minimal chance of PORC, is thought to be of benefit.

The difficult intubation is another aspect where Sugammadex may be of use. A difficult intubation may result in an inability to secure tracheal intubation and thus oxygenation. This is a particular fear of novice anaesthetists starting their first on call shifts. Typical patients were difficult intubation can be a problem are the obstetric population and the obese.

Conventional and current teaching, for a rapid sequence induction involves the use of Suxamethonium, a depolarising NMB, as a rapid acting muscle relaxant to aid intubation. Suxamethonium wears off within approximately 7 minutes and spontaneous breathing will start to occur (7). With pre-oxygenation, theoretically the time period of apnoea may be small enough that the patient will not become hypoxic. There is evidence that the time to desaturation is quicker than the time it takes suxamethonium to wear off. In the 'Can't Intubate, Can't Ventilate' situation, with no ability to oxygenate the patient, this would result in a period of hypoxia before spontaneous respiration returns.

It has been shown in many studies that the reversal of NMB with rocuronium using Sugammadex is quicker than the spontaneous recovery after suxamethonium. Using an intubating dose of Rocuronium and then being able to give Sugammadex to reverse the Rocuronium is gaining favour for the difficult airway scenario.

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Case Example

A 48-year-old woman is scheduled for a laparoscopic cholecystectomy. She has suffered several episodes of acute cholecystitis from which she has now recovered. Her USS shows a number of gallstones in the gall bladder.

She is otherwise fit and well but is morbidly obese with a BMI of 49. She weighs 120 kg.

The anaesthetic considerations are to provide safe anaesthesia for laparoscopic surgery in a patient who has morbid obesity. The surgeon requires good operating conditions with a good working space and view to remove the gall bladder by a laparoscopic technique.

The anaesthetist uses a formula of ideal body weight plus 30% to calculate the dose of the NMB Rocuronium. He gives a dose of 80 mg and monitors the depth of neuromuscular block using a nerve stimulator. Anaesthesia is provided with the volatile anaesthetic agent Desflurane and analgesia with the opioid Fentanyl. Both drugs are suitable for use in this case to allow a good recovery from anaesthesia.

The surgery takes 45 minutes and is difficult because of a lot of adhesions from the previous episodes of inflammation around the gall bladder.

The anaesthetist has given a top up of 20 mg of Rocuronium after 30 minutes to maintain a deep level of NMB and prevent loss of muscle relaxation during the surgical procedure.

At the end of surgery there is just one twitch of the TOF. Use of conventional reversal (Neostigmine 2.5mg and Glycopyrrolate 0.5mg) at this point would not result in adequate reversal, due to the depth of muscle relaxation. To ensure safe reversal the anaesthetist must wait for the relaxant to wear off until 3 or more train of four twitches are visible. This has timing implications for continuing the list. To ensure complete reversal of the NMB, at this point, he uses 480mg Sugammadex at the recommended dose of 4mg/kg based on actual body weight.

At the end of surgery the patients is awake and pain free with full return of muscle power.

In this case Sugammadex has allowed reversal from a deep level of NMB, which would not have been possible safely with Neostigmine, at that time. Complete reversal is achieved without any concerns for postoperative residual curarisation and return of full airway reflexes.

Conclusion

In summary, this article has introduced some neuromuscular blocking drugs that are in common use in anaesthetics. We have described what methods are used and how anaesthetists monitor neuromuscular blockade during surgery. The reversal of this neuromuscular blockade is imperative by the end of surgery and we have looked at which agents are used for this in routine practice.

Inadequate reversal of neuromuscular block can be dangerous and patients can suffer as a result. We have introduced the novel agent, Sugammadex, which is being used more frequently in the last 10 years. There are specific cases where Sugammadex is indicated, the obese or obstetric population, and particularly the difficult airway scenario. We have used a theatre-based case to help illustrate Sugammadex's use. However, at present, the cost of Sugammadex may limit it widespread clinical use as a routine reversal of neuromuscular blockade.

Best of 5 Multiple Choice Questions

1) The following are neuromuscular blocking agents that can be reversed with Sugammadex?

a) Atracurium

b) Cis-atracurium

c) Rocuronium

d) Neostigmine

e) Glycopyrrolate

2) Which of the following may occur as a result of inadequate reversal from neuromuscular blockade?

a) Increased respiratory complications and awareness of paralysis

b) Shorter stay in recovery

c) Lower rating on a visual analogue score for pain

d) Normal SpO2 in recovery

e) Increased pharyngeal tone and shorter time to return of airway reflexes

MECHANISM OF ACTION, MONITORING & REVERSAL OF NEUROMUSCULAR BLOCKING AGENTS - THE USE OF SUGAMMADEX

T Jacobs, MV Copp

Answers

1. Answer is (C)

Neuromuscular blocking agents are split into depolarising (ie suxamethonium) and non-depolarising neuromuscular blocking agents. The non-depolarising drugs are then split again into two groups:

A) Benzylisoquinolinium

B) Aminosteroids

This article refers mainly to the aminosteroid group (e.g. Rocuronium and Vecuronium). These aminosteroids can be reversed by using Sugammadex. Atracurium and Cis-atracurium are in the Benzylisoquinolinium and mainly undergo spontaneous Hoffman degradation.

Neostigmine is an Acetylcholinesterase inhibitor (or called an anticholinesterase). It increases the amount of acetylcholine in the neuromuscular junction and so does act as a reversal for the neuromuscular blockers but does not involve Sugammadex and is not reversed by Sugammadex.

Glycopyrrolate is an anti-muscarinic drug. It is given in conjunction with Neostigmine with an aim to offset the widespread muscarinic effects that Neostigmine will have on multiple systems.

2. Answer is (A)

Postoperative residual curarisation (PORC) has important morbidity and mortality considerations with use of neuromuscular blockade. Current practice would be to obtain a Train-of-Four (ToF) ratio of >0.9 prior to extubation in order to limit this risk. This used to be >0.7 but numerous papers suggested higher complications occurred at this level.

At levels of ToF less than 0.7 there is increased atelectasis and pneumonia post operatively. This also includes a reduced airflow and response to hypoxic ventilator drive.

At ToF less than 0.8 there is poor swallow coordination and higher risk of airway obstruction

At ToF less than 0.9, can lead to a longer stay in the recovery room and higher risk of hypoxaemia. The unpleasant sensation of residual paralysis may also occur at these under-reversed levels.

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THE EARLY WARNING SCORES IN A DISTRICT GENERAL TEACHING HOSPITAL: THE INFLUENCE OF THE INTRODUCTION OF THE NATIONAL EARLY WARNING SCORES (NEWS) SYSTEM

JD Heffernan, FA Brohi

The Early Warning Scores In A District General Teaching Hospital: The Influence Of The Introduction Of The National Early Warning Scores (News) System
Teaching & Training

Abstract

The recognition of acutely ill and deteriorating patients has been a key issue in medicine for many years. This was brought into sharp focus with the introduction of critical care outreach teams in the 1990s. Since then scoring systems have been introduced to aid in this recognition and to target escalation to senior or specialist care. In 2007 NICE recommended that scoring systems should be used in all acute settings.

Each trust designed their own systems. In 2012 a National early warning scoring (NEWS) system was launched. In this paper we compare rates and accuracy of escalation in our trust from 2012 when an early example of 'Track and Trigger' chart was in use with rates using the NEWS system. The completeness of the observation chart and accuracy of score calculation are also investigated. Our results show a score-lead escalation rate in 2015 of more than double that in 2012.

Introduction

Medical observation charts have been in use since the end of the 19th century following the introduction of clinical thermometry by Carl Wunderlich in 1868 (1). By the early 20th century it was noticed that the pattern of observations could be used in the diagnosis of various conditions and illnesses as well as in the recognition of sick patients(2).

By the1990's feedback from the newly formed critical care outreach teams highlighted the need for a means of using this data to give an early warning of a patients deterioration in order to seek prompt escalation(3–5).

The now ubiquitous concept of an early warning score where physiological parameters were judged against set criteria to mandate escalation did not attain a substantive form until 2001 with the publication of a validated 'modified' early warning score by Subbe and co-workers(6).

Following this most hospitals implemented their own 'early warning' (EWS) or 'track and trigger' (TTS) systems broadly based on the 'Modified Early Warning Score' (MEWS). The use of these scoring systems have since been extensively studied and high scores were found to correlate to a higher risk of mortality(7,8) and hence identify patients in need of escalation; ward based or via critical care outreach etc. However by 2007 a Cochrane review indicated that the impact on mortality was still unclear(9).

Also in 2007 it was noted that there was considerable variation between EWS and TTS systems in hospitals in the UK and the Royal College of Physicians report "Acute medical care: the right person, in the right setting - first time" recommended a standardized EWS system for the UK; an 'NHS EWS' (NEWS); latterly National Early Warning System(10). The NICE clinical guideline CG50 detailing the recognition and response to acute illness was published in 2007(11). This recommended the use of a physiological track and trigger system but did not prescribe a national system.

This was realized in 2012 with the Royal College of Physicians Report "National Early Warning Score (NEWS): Standardising the assessment of acute-illness severity in the NHS". This outlined in detail the new scoring system including the format and layout of the charts (12).

Our trust implemented this new system very soon after this publication.

In this paper we compare two sets of data that on the completion of these charts and the actions following a high ("triggering") score. The first was conducted in 2012 when the trust was using its own EWS chart(13). The second set of data is from an unprocessed audit on observation charts with data collected in the first part of 2015 with the NEWS chart in use (14). We set out to look for two characteristics in the data:

The Differences in observation set completion and score accuracy.

and

The Rate of 'Triggering' of an escalation
and The accuracy of the subsequent escalation.

THE EARLY WARNING SCORES IN A DISTRICT GENERAL TEACHING HOSPITAL: THE INFLUENCE OF THE INTRODUCTION OF THE NATIONAL EARLY WARNING SCORES (NEWS) SYSTEM

JD Heffernan, FA Brohi

Methods

The data from the two Audits were analysed; looking for comparable data. Where possible the most complete, pre-analysis data-sets were used. There were obvious differences in the two audits but it was felt there was a significant amount of comparable data with which to work. It is important to note that the 2015 data is from an ongoing audit and has not been crosschecked statistically.

The basic features of the two audits are summarised in table 1.

	2012 EWS Audit	2015 NEWS Audit
Purpose	EWS Accuracy Audit vs CG50	General NEWS Audit vs CG50
Number of 'Observations'	502	359
Patient Assignment	Random	Random
Data points per patient	3	1
Data Collection Window	3 Months	3 Months
Hospital areas	Orthopaedics and Surgery	Orthopaedics, Surgery & Acute Medicine.
Domains	Observations Recorded including urine output Score Calculated Correctly Score Deviation from Correct Action Taken ICU Admission	Observations Recorded Score Totalled Score Calculated Correctly inc Urine output Monitoring plan change Observation Frequency Action Taken ICU admission Sepsis AKI

Table 1: Overview of The Audits.

From the above data the most striking difference is the areas of the hospital from which the data was gathered. To address this we re-analysed the 2015 data and found that it was possible to divide the data by ward. Isolating the data from surgery and orthopaedics gave 125 observations across 125 patients.

The data fields of each audit were compared and list of comparable data was produced. The data was then sorted into these categories and analysed empirically using Microsoft excel.

Results

The numerical results are shown in Table 2 below. Alongside the 2012 EWS audit the results for the whole cohort of the 2015 data are presented alongside the results for Surgical and Orthopaedic audits alone.

	2012 EWS Audit		2015 News Audit Full Cohort		2015 News Audit: Surgical and orthopaedic patients only	
Data Label	**Value**	**%**	**Value**	**%**	**Value**	**%**
1. Number of Observations	502		359		125	
Number of Patients	168		359		125	
Completion of Observations						
2. Complete Records	485/502	96.6%	332/359	88.3%	114/125	91.2%
3. Incomplete Records	17/502	3.4%	27/359	7.5%	11/125	8.8%
Heart rate	0/17	0	4/27	14.8%	1/11	9.1%
Resp. Rate	13/17	76%	2/27	7.4%	2/11	18.2%
Temperature	3/17	17.6%	8/27	29.6%	6/11	54.5%
Blood Pressure	1/17	5.9%	0/27	0	0/11	0
Oxygen Saturation (SpO2)	0/17	0	8/27	29.6%	1/11	9.1%
AVPU	0/17	0	8/27	29.6%	2/11	18.2%
Score Mis-Calculation						
4. EWS Calculated*	485/502	96.6%	326/332	98.9%	111/114	97.4%
EWS Miscalculated	48/485	9.9%	43/326 (+3 nr**)	12.3%	12/111 (+2nr)	10.8%
Correct Score and Escalation						
5. Correct calculation of Score	437/485	90.1%	283/332	85.2%	97/114	85.0%
No action needed	366/437	83.7%	168/283	59.4%	61/97	62.8%
Escalation needed	71/437	16.3%	115/283	40.6%	36/97	37.1%
Escalated appropriately	68/71	95.6%	107/115	93.0%	33/36	91.7%

Table 2: Results of Audit Comparison.

**Scores absent from the chart were counted as 'miscalculated' and not recorded separately.*
*** nr=Not recorded in the Audit paperwork.*

The above results show that there is a small drop in complete records from 96.6% to 91.2% corresponding to a rise of incomplete records since the introduction of NEWS system (3.4% v 8.8%). The most common parameter not recorded in 2015 audit cycle is the patient's temperature; the rate of none-recording which has increased significantly from 17.6% to 54.5%. There was no failure to record heart rate, oxygen saturation and AVPU in 2012 audit but in 2015 audit cycle there was failure in recording these parameters in some cases.

Some scores were uncalculated in both the audits but there was a small overall rise in calculated scores in 2015 in comparison to 2012 (96.6% v 97.4%).

In a high proportion of cases calculation was correct with appropriate escalation, however these scores were better in 2012 audit cycle in comparison to 2015 audit cycle (9.9% v 10.8%).

Discussion

Completeness of Observations and Score Accuracy

Number of Observations and Validity of comparison

There was a difference in data collection method in the two audits; in 2012 audit three observations were made for each patient but in 2015 audit cycle one observation was recorded per patient. However, the total number of observations are comparable in both audit cycles (502 v 359). It must be noted that although the number of patients audited in this surgical/orthopaedic arm of 2015 is comparable to 2012 audit (125 v 168), the number of observations is much less (502 v 125). The validity of this comparison is supported by the broad consistency between the whole cohort of the 2015 audit and the surgical/orthopaedic arm.

Completion of Observations

It is encouraging to note that there is a high rate of completion of the observations although a fall from the 2012 EWS Audit completion rate to the 2015 NEWS audit completion rate was noted (96.9 v 91.2%).

It was expected that similar categories would be omitted across both audits; it is interesting to note the spread of omissions in the NEWS Audit observations compared to the sharp concentration within fewer categories (mostly respiratory rate data) in the EWS audit. This is shown Graphically in the Figures 1-3 on the next page.

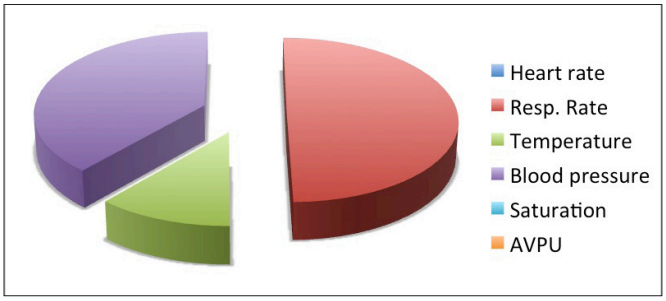

Figure 1: Record Omissions 2012 EWS Charts.

THE EARLY WARNING SCORES IN A DISTRICT GENERAL TEACHING HOSPITAL: THE INFLUENCE OF THE INTRODUCTION OF THE NATIONAL EARLY WARNING SCORES (NEWS) SYSTEM

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Figure 2: Record Omissions, 2015 NEWS Charts. Whole cohort.

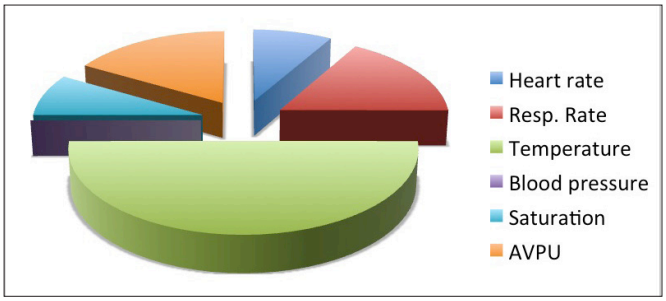

Figure 3: Record Omissions, 2015 NEWS Charts. Surgical/Orthopaedic Arm Only.

Score Calculation

The scores were miscalculated by between 9 and 13 percent. Although at first glance these gave broadly similar numbers it was surprising to see a rise in the miscalculation rate by 20% in the 2015 (whole cohort) audit.

Overall these sections see an apparent deterioration in both score completion and calculation accuracy from the 2012 News Audit. The reasons for this are difficult to determine with this data. At first glance the NEWS chart contains more sets observations across its page; when full it can appear more 'cluttered' than the old EWS chart. Please refer to Figures 4 and 5 for a comparison. There could also still be an element of unfamiliarity with the NEWS scoring system.

It is worth noting that the numbers of missed calculations and missed observations are small and the 2015 data is raw and still to be completed hence small variations should be considered appropriately.

Escalation Rate and Escalation Accuracy

Escalation Rate

The most striking difference between the 2012 EWS audit and the 2015 NEWS audit is the numbers of observations that trigger escalation. In both the whole cohort and the surgical/orthopaedic arm the percentage of observations that trigger escalation is more than double. This is shown graphically in figures 4 to 6 below.

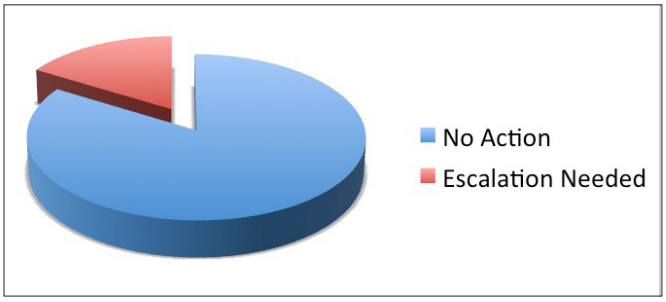

Figure 4: Escalation Rate, 2012 EWS Charts.

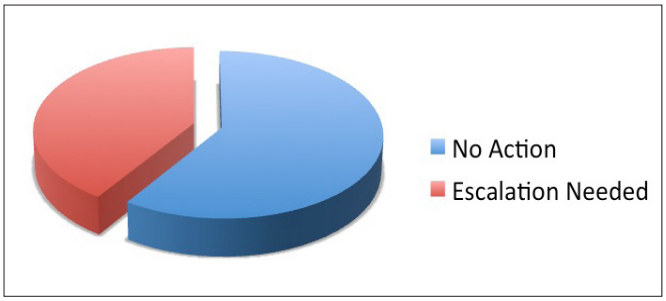

Figure 5: Escalation Rate, 2015 NEWS Charts. Whole cohort.

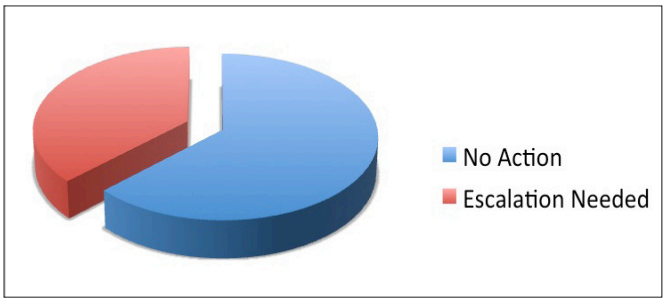

Figure 6: Escalation Rate, 2015 NEWS Charts. Surgical/Orthopaedic Arm Only.

In essence it would appear that patients under the NEWS system are escalated at a much earlier point than under the older EWS track and trigger system.

In order to explore this in more detail it is necessary to look at the two systems in detail.

They both comprise of a colour coded chart into which observations are entered. An observation will be scored according to its value as detailed on the chart and indicated by the colour of the chart cell colour.

The Charts of both systems are shown in Figures 7 and 8.

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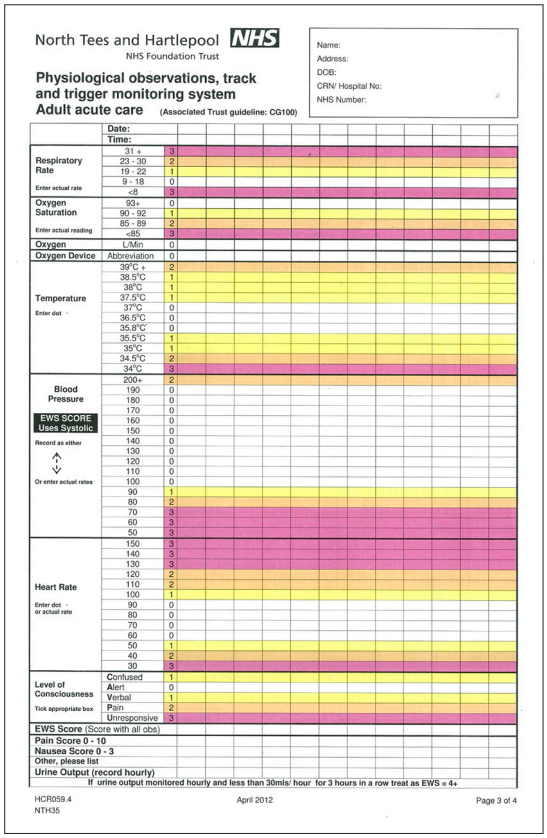

North Tees and Hartlepool NHS
NHS Foundation Trust

Physiological observations, track and trigger monitoring system Adult acute care (Associated Trust guideline: CG100)

Name:
Address:
DOB:
CRN/ Hospital No:
NHS Number:

Date:
Time:

Respiratory Rate	31 +	3
	23 - 30	2
	19 - 22	1
	9 - 18	0
Enter actual rate	<8	3
Oxygen Saturation	93+	0
	90 - 92	1
	85 - 89	2
Enter actual reading	<85	3
Oxygen	L/Min	0
Oxygen Device	Abbreviation	0
Temperature	39°C +	2
	38.5°C	1
	38°C	1
	37.5°C	1
Enter dot ·	37°C	0
	36.5°C	0
	35.8°C	0
	35.5°C	1
	35°C	1
	34.5°C	2
	34°C	3
Blood Pressure	200+	2
	190	0
	180	0
	170	0
EWS SCORE Uses Systolic	160	0
	150	0
Record as either	140	0
	130	0
	120	0
Or enter actual rates	110	0
	100	0
	90	1
	80	2
	70	3
	60	3
	50	3
Heart Rate	150	3
	140	3
	130	3
	120	2
	110	2
	100	1
Enter dot · or actual rate	90	0
	80	0
	70	0
	60	0
	50	1
	40	2
	30	3
Level of Consciousness	Confused	1
	Alert	0
	Verbal	1
Tick appropriate box	Pain	2
	Unresponsive	3
EWS Score (Score with all obs)		
Pain Score 0 - 10		
Nausea Score 0 - 3		
Other, please list		
Urine Output (record hourly)		

If urine output monitored hourly and less than 30mls/ hour for 3 hours in a row treat as EWS = 4+

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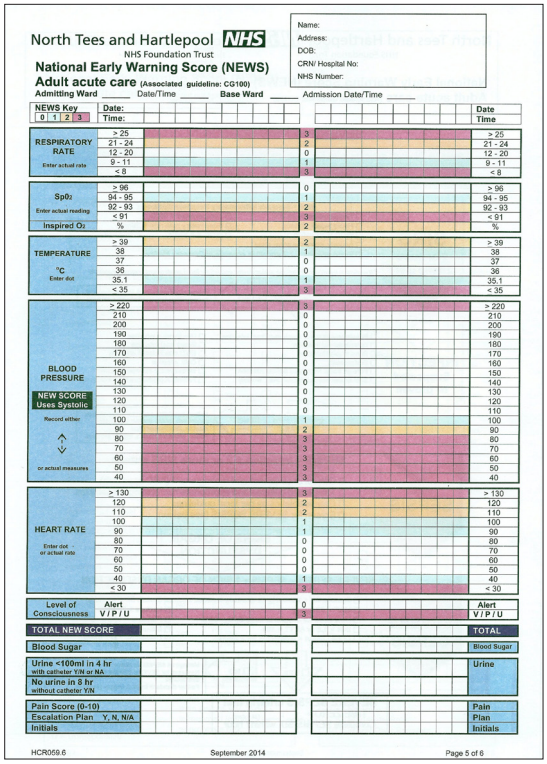
Figure 7: Track and Trigger Chart, 2012.



North Tees and Hartlepool NHS
NHS Foundation Trust

National Early Warning Score (NEWS) Adult acute care (Associated guideline: CG100)

Admitting Ward _____ Date/Time _____ Base Ward _____ Admission Date/Time _____

Name:
Address:
DOB:
CRN/ Hospital No:
NHS Number:

NEWS Key 0 1 2 3	Date: Time:		Date Time
RESPIRATORY RATE	> 25	3	> 25
	21 - 24	2	21 - 24
	12 - 20	0	12 - 20
	9 - 11	1	9 - 11
Enter actual rate	< 8	3	< 8
SpO2	> 96	0	> 96
	94 - 95	1	94 - 95
	92 - 93	2	92 - 93
Enter actual reading	< 91	3	< 91
Inspired O2	%	2	%
TEMPERATURE	> 39	2	> 39
	38	1	38
°C	37	0	37
	36	0	36
Enter dot	35.1	1	35.1
	< 35	3	< 35
BLOOD PRESSURE	> 220	3	> 220
	210	0	210
	200	0	200
	190	0	190
	180	0	180
	170	0	170
	160	0	160
	150	0	150
	140	0	140
NEW SCORE Uses Systolic	130	0	130
	120	0	120
	110	0	110
Record either	100	1	100
	90	2	90
	80	3	80
	70	3	70
	60	3	60
or actual measures	50	3	50
	40	3	40
HEART RATE	> 130	3	> 130
	120	2	120
	110	2	110
	100	1	100
	90	1	90
	80	0	80
Enter dot or actual rate	70	0	70
	60	0	60
	50	0	50
	40	1	40
	< 30	3	< 30
Level of Consciousness	Alert V / P / U	0 3	Alert V / P / U
TOTAL NEW SCORE			TOTAL
Blood Sugar			Blood Sugar
Urine <100ml in 4 hr with catheter Y/N or N/A			Urine
No urine in 8 hr without catheter Y/N			
Pain Score (0-10)			Pain
Escalation Plan Y, N, N/A			Plan
Initials			Initials

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Figure 8: NEWS Chart, 2015.

The different thresholds for each score can be seen as well as certain additions in the NEWS chart (such as a score of 2 added if oxygen is being administered).

Along with this each system has a 'rubric' with which to interpret the score and determine the action taken.

The triggering and escalation rubrics are summarized in Table 3 below.

Score	EWS Chart	Score	NEWS Chart
0 - 1	Continue to monitor: No further action unless otherwise concerned. 4 Hourly Observations.	0-1	Continue to monitor: No further action unless otherwise concerned. 4 Hourly Observations.
2-3	Inform Nurse in Charge. Increase Observation Frequency A to E assessment and confirm observations*.	2-4	Inform Nurse in Charge. RGN to check Observations A to E assessment : Interventions as appropriate Escalation if required (SBAR) 4 Hourly Observations; increased if required
4-5 or single parameter of 3	A to E assessment and confirm observations. Urgent call to patient's primary medical team or senior matron using SBAR. Escalate until a plan is agreed.	5-6	Inform Nurse in Charge. RGN to check Observations A to E assessment. Immediately contact Ward Doctor Complete trigger protocol on chart Hourly Observations Doctor to assess patient; formulate management plan; Senior review if no improvement in 30 minutes.
>=6	Emergency call to patients primary medical team Inform Critical care anaesthetist A to E assessment and confirm observations. Crash call if appropriate.	>=7	Urgently: Inform Nurse in Charge. Urgently: A to E assessment. Urgently: Escalate to senior doctor (or senior matron) Doctor to immediately review and implement management plan.

Table 3: A Comparison of Trigger Levels.

Again these aspects of the two systems show many similarities but with differences in threshold. It appears that the NEWS system ascribes more points for lesser changes in physiology. It also appears that this is compensated for (in part) by higher action thresholds within the rubric.

To explore this further it may be useful to consider a typical patient. A gentleman in his 60's; admitted for surgery who was found to have community acquired pneumonia and had the following Observations taken whilst on the ward:

Blood pressure: 105/65mmHg
Pulse: 90/min (regular)
Temperature: 38.4°C
Respiratory rate: 22/min

He has been placed on nasal cannula just now and is saturating to 93%.

Under the EWS track and trigger system he would score just 2. Warranting no further action (although could still be escalated if there was concern or a 'gut feel' according to the EWS system). However under the NEWS system he would score 9 warranting urgent senior review.

This simple exercise illustrates how the NEWS score can be more sensitive than our previous system in flagging up a deteriorating patient. Of course not scoring on a chart would not mean our patient would be overlooked under the old system as it is not a replacement for the clinical acumen of experienced nursing staff but it would alert an inexperienced HCA who is performing routine observations that something is wrong.

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The reasons for this sensitivity are likely to lie with both the score thresholds for each observation as well as threshold in the rubric. A new addition the chart is the score of '2' for the administration of oxygen. This has a significant impact on the final. It is interesting to note that this is one of the recommendations following the 2012 Audit by du Plessis and Brohi (13).

Accuracy Of Escalation

In both audits the patients that needed escalation were done so correctly in the vast majority of cases. However this is once again not as high as in the 2012 audit (91.7% v 95.6%). It is possible that the NEWS system is flagging up some 'false positives' that are ruled out on early assessment and not recorded as an 'escalation'. It is noted that despite this they should have been properly documented as such. It is also worth noting that escalating 40% of the patients on the ward; even if it for increased observation rate only it would represent an increase in workload. As before it is important to recognize that the 2015 audit data is still raw and incomplete.

Conclusion and Recommendations

It is our conclusion from this study that the new National Early Warning Score system does provide a means to recognize and escalate acutely ill and deterioration promptly. Furthermore it appears to be a much more sensitive tool than other typical 'Track and Trigger' EWS charts that predated it.

Introduction of any new tool is not without negative aspects. There is always a process of getting used to new systems. Any tool that demands increased awareness and increased vigilance for a large proportion of patients will have a resource implication and the effect of this could possibly be seen in this study. However it is our conclusion that on balance the impact of this is far outweighed by the benefits of increased sensitivity.

Some fine detail in the 2015 data indicates that the increased escalation rate has no negative effects on the patients with the highest scores with early data indicating a 100% correct escalation route for those. It is hoped that once complete, a more detailed analysis of the 2015 data will lead to firmer conclusions in this area.

Although not possible with this data as it stands it would be useful to see a statistical treatment of the NEWS system and a numerical expression of its sensitivity and specificity.

Meanwhile it is recommended that Trusts such are ours continues their training and education programs on these systems for existing and new staff including junior doctors and it is hoped that this paper will help to that end.

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