The Final FRCA Constructed Response Questions

A Practical Study Guide

Second Edition

Elizabeth Combeer and Mitul Patel

Illustrations by Paul Hatton

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This up-to-date study guide for the Final FRCA CRQ comprises questions based on every topic examined in the Royal College of Anaesthetists' Final written exam from the past 12 years. It therefore covers the areas of the syllabus that are key to exam success, offering factual learning and the opportunity to practise CRQ-style questions, with chapters that reflect the RCoA syllabus format to help organise learning.

The inclusion of diagrams and additional commentary ensure that that this book will help candidates to learn rather than just providing a list of suggested model answers. Advice is offered about revision approaches, best sources of learning for the examination, and guidance on structuring answers, which will support exam success in all parts of the Final FRCA. This resource will save hours of work for anaesthetists preparing for the Final FRCA.

Elizabeth Combeer BSc, MBBS, MRCP, FRCA, MA, is an anaesthetic consultant at Frimley Health NHS Foundation Trust and runs the FRCA teaching programme at Frimley Park Hospital. Her close involvement with trainees preparing for the FRCA exams means that she understands the requirements and level of knowledge needed to pass this assessment.

Mitul Patel MBBS, BSc, FRCA, is an anaesthetic registrar in South London with an interest in medical education.

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CONTENTS

ABBREVIATIONS

A-a	Alveolar-arterial
AAA	Abdominal aortic aneurysm
AAGBI	Association of Anaesthetists of Great Britain and Ireland
ABG	Arterial blood gas
ACE	Angiotensin-converting enzyme
AChR	Acetylcholine receptor
ACT	Activated clotting time
ADP	Adenosine diphosphate
AKI	Acute kidney injury
ALS	Adult life support
ALT	Alanine transaminase
APL	Adjustable pressure limiting
AT	Anaerobic threshold
ATP	Adenosine triphosphate
APRV	Airway pressure release ventilation
ARDS	Acute respiratory distress syndrome
ASA	American Society of Anesthesiologists
AVPU	Alert, voice, pain, unresponsive
BJA	*British Journal of Anaesthesia*
BNF	*British National Formulary*
BP	Blood pressure
bpm	Beats per minute
BMI	Body mass index
BNP	Brain natriuretic peptide
BSA	Body surface area
CABG	Coronary artery bypass graft
cAMP	Cyclic adenosine monophosphate
CAPD	Continuous ambulatory peritoneal dialysis
CBG	Capillary blood glucose
CBT	Cognitive behavioural therapy
CEACCP	*Continuing Education in Anaesthesia, Critical Care and Pain*
CICO	Can't intubate, can't oxygenate
CK	Creatine kinase
CKD	Chronic kidney disease
CMR	Cardiac MRI
$CMRO_2$	Cerebral metabolic rate of oxygen
CMV	Cytomegalovirus
CNS	Central nervous system
COETT	Cuffed oral endotracheal tube
COPD	Chronic obstructive pulmonary disease
COVID	Disease due to severe acute respiratory syndrome coronavirus 2
COX	Cyclic oxygenase
CPAP	Continuous positive airway pressure
CPB	Cardiopulmonary bypass
CPET	Cardiopulmonary exercise testing
CPOC	Centre for Perioperative Care
CPP	Cerebral perfusion pressure
CPR	Cardiopulmonary resuscitation
CRP	C-reactive protein
CRPS	Complex regional pain syndrome
CRQ	Constructed response question
CSE	Combined spinal and epidural
CSF	Cerebrospinal fluid
CT	Computed tomography
CTPA	Computed tomography pulmonary angiogram
CVC	Central venous catheter
CVP	Central venous pressure
CXR	Chest radiograph
2,3 DPG	2,3 Diphosphoglycerate
DAPT	Dual antiplatelet therapy
DAS	Difficult Airway Society
DES	Drug-eluting stent
DIC	Disseminated intravascular coagulation
DLCO	Diffusing capacity of the lungs for carbon monoxide
DKA	Diabetic ketoacidosis
DOP	Delta opioid receptor
DVT	Deep vein thrombosis
EBV	Epstein-Barr virus
ECG	Electrocardiogram
Echo	Echocardiogram
ECMO	Extracorporeal membrane oxygenation
ED	Emergency department

EEG	Electroencephalogram
eGFR	Estimated glomerular filtration rate
EMG	Electromyogram
ENT	Ear, nose and throat
ERAS	Enhanced recovery after surgery
ERCP	Endoscopic retrograde cholangiopancreatography
ESR	Erythrocyte sedimentation rate
ESRF	End-stage renal failure
$etCO_2$	End-tidal carbon dioxide
ETT	Endotracheal tube
EVAR	Endovascular aneurysm repair
FEV_1	Forced expiratory volume in 1 second
FiO_2	Fraction of inspired oxygen
FRC	Functional residual capacity
FRCA	Fellowship of the Royal College of Anaesthetists
GA	General anaesthetic
GBS	Guillain-Barré syndrome
GIRFT	Getting It Right First Time
GMC	General Medical Council
GCS	Glasgow Coma Scale
GGT	Gamma-glutamyl transferase
GORD	Gastro-oesophageal reflux disease
GPAS	Guidelines for the provision of anaesthetic services
GTN	Glyceryl trinitrate
$5HT_3$	Serotonin (5-hydroxytryptamine)
HbA1c	Glycosylated haemoglobin
HDU	High dependency unit
HELLP	Haemolysis, elevated liver enzymes and low platelets syndrome
HFNO	High-flow nasal oxygen
HFOV	High-frequency oscillatory ventilation
HIV	Human immunodeficiency virus
HOCM	Hypertrophic obstructive cardiomyopathy
HSV	Herpes simplex virus
IASP	International Association for the Study of Pain
ICD	Implantable cardiac defibrillator
ICP	Intracranial pressure
ICU	Intensive care unit
ID	Internal diameter
IR	Interventional radiology
INR	International normalised ratio
IQ	Intelligence quotient
ITP	Immune thrombocytopenic purpura
Iu	International units
iv	Intravenous
IVC	Inferior vena cava
ivi	Intravenous infusion
JAK	Janus kinase
JVP	Jugular venous pressure
KOP	Kappa opioid receptor
LMA	Laryngeal mask airway
LMWH	Low molecular weight heparin
LocSSIP	Local safety standard for invasive procedure
LVEDP	Left ventricular end-diastolic pressure
LVEF	Left ventricular ejection fraction
M&M	Morbidity and mortality
MAC	Minimum alveolar concentration
MAP	Mean arterial pressure
MCV	Mean corpuscular volume
MDT	Multidisciplinary team
MEOWS	Modified Early Obstetric Warning Score
MHRA	Medicines and Healthcare Products Regulatory Agency
MEP	Motor evoked potential
MI	Myocardial infarction
MIBG	Meta-iodobenzylguanidine nuclear medicine scan
MOP	Mu opioid receptor
MRI	Magnetic resonance imaging
MRSA	Methicillin-resistant *Staphylococcus aureus*
MSSA	Methicillin-sensitive *Staphylococcus aureus*
NAP	National Audit Project (of the Royal College of Anaesthetists)
NCEPOD	National Confidential Enquiry into Patient Outcome and Death
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NICU	Neonatal intensive care unit
NIV	Noninvasive ventilation
NMBD	Neuromuscular blocking drug
NMDA	N-methyl-D-aspartate glutamate receptor
NPSA	National Patient Safety Agency
NSAIDs	Nonsteroidal anti-inflammatory drugs
NYHA	New York Heart Association
OAA	Obstetric Anaesthetists' Association

ODP	Operating Department Practitioner
OSA	Obstructive sleep apnoea
OSCE	Objective structured clinical examination
PACU	Post-anaesthetic care unit
PaO_2	Partial pressure of oxygen in arterial blood
$PaCO_2$	Partial pressure of carbon dioxide in arterial blood
PCA	Patient-controlled analgesia
PCEA	Patient-controlled epidural analgesia
PCI	Percutaneous coronary intervention
PCR	Polymerase chain reaction
PCT	Percutaneous tracheostomy
PEA	Pulseless electrical activity
PEEP	Positive end-expiratory pressure
PEG	Percutaneous endoscopic gastrostomy
PEJ	Percutaneous endoscopic jejunostomy
PET	Positron emission tomography
POETTS	Perioperative Exercise Testing and Training Society
PONV	Postoperative nausea and vomiting
PPI	Proton pump inhibitor
PRES	Posterior reversible encephalopathy syndrome
ROTEM	Rotational thromboelastometry
RQ	Respiratory quotient
RSI	Rapid sequence induction
SAD	Supraglottic airway device
SALG	Safe Anaesthesia Liaison Group
SAQ	Short answer question
SBP	Systolic blood pressure
SGLT-2	Sodium-glucose co-transporter-2
SIADH	Syndrome of inappropriate antidiuretic hormone
S1Q3T3	S wave in lead 1, Q wave and inverted T wave in lead 3
SLE	Systemic lupus erythematosus
SNRI	Serotonin-noradrenaline reuptake inhibitor
SSRI	Selective serotonin reuptake inhibitor
SvO_2	Mixed venous oxygen saturations
SVR	Systemic vascular resistance
SVRI	Systemic vascular resistance index
TAP	Transversus abdominis plane
TBSA	Total body surface area
TCA	Tricyclic antidepressant
TCI	Target-controlled infusion
TEG	Thromboelastrography
TENS	Transcutaneous electrical nerve stimulation
TIA	Transient ischaemic attack
TIVA	Total intravenous anaesthesia
TNF	Tumour necrosis factor
TSH	Thyroid-stimulating hormone
TURP	Transurethral resection of the prostate
VAE	Venous air embolism
VAP	Ventilator associated pneumonia
VATER	Syndrome of vertebral, cardiac, renal and limb anomalies, tracheo-oesophageal fistula and anal atresia
vCJD	Variant Creutzfeldt-Jakob disease
VCO_2	Carbon dioxide production
VF	Ventricular fibrillation
VO_2 max	Maximal oxygen consumption
VRIII	Variable rate intravenous insulin infusion
VT	Ventricular tachycardia
VTE	Venous thromboembolism
V/Q	Ventilation: perfusion
vWF	von Willebrand factor
WHO	World Health Organization

PASSING THE FINAL CRQ

These are my top tips for approaching the Final CRQ. They are based on what I find myself saying repeatedly at weekly teaching with the trainees at Frimley.

Print a copy of the syllabus

Both core and intermediate-level syllabuses are tested in the Final. I know these are dauntingly large documents, but it really is important that you understand the breadth of what you need to learn, and looking at these helps you direct your reading. Revision for subspecialties such as burns, cardiothoracics, neuro, paediatrics and obstetrics can largely be covered by searching for CEACCP or BJA Education articles that relate to the specified learning objectives. In this way, you will be learning the College-approved facts on the subject. There is also a very strong link between topics addressed in the exam and topics that have featured in these articles within the preceding two years. Every time you do some revision that relates to something on the syllabus, cross it off. Remember that a broad understanding is more important than learning a few topics in great detail.

Three types of questions

There are three main types of questions in the Final CRQ. Firstly, there are those that relate to new guidance or reports (such as National Audit Projects or National Institute for Health and Care Excellence guidance). Secondly, there are the questions that test knowledge of the manner of anaesthesia provision for specific operations or in particular situations. The third group assesses knowledge of how particular patient conditions impact on anaesthesia management. Sometimes, they mix all of these in together. Very often, questioning on facts seemingly very specific to the Primary FRCA are thrown into the mix as well, so ignore the basic sciences at your peril!

Questions relating to new guidance or reports

Questions based on these topics tend to feature within two years of their publication. Search the likely websites (Royal College of Anaesthetists, Difficult Airway Society, Obstetric Anaesthetists' Association, National Institute for Health and Care Excellence, Association of Anaesthetists) and be aware of new national guidelines that are implemented in your place of work. Also, be aware of topical causes of medical error, such as new additions to the list of never events that are relevant to anaesthesia and statements and alerts from the Safe Anaesthesia Liaison Group. Think about the impact of these guidelines at the organisational level, not just at the point of delivery of anaesthesia.

Questions relating to the anaesthetic management of a specific operation or situation

This includes questions about nerve blocks as well. Specific nerve blocks have peaks of popularity and the timing of inclusion of questions about them in the CRQ reflects this. Remember to learn

the specific complications of such blocks, not just "bleeding, infection, nerve damage." It is by listing the specific complications that you demonstrate that you actually know the relevant anatomy.

When considering the anaesthetic management of any operation, think in terms of preoperative, intraoperative and postoperative. Preoperatively, consider history, examination and investigations. However, in no section of the exam should you ever state that you would "take a full history, examine the patient and request ECG, FBC and U&E." Instead, you need to take a much more targeted approach, especially in the CRQ. Specify why you are asking this question in this particular patient, what you are seeking in the examination of this particular patient, or what investigation anomalies may be found in this particular patient. Intraoperatively, consider mode of anaesthesia, airway management, positioning and its impact, likely duration and its impact, need for warming, thromboprophylaxis, particular needs for monitoring, risk of bleeding and any special issues relating to this type of surgery. This is all as you would in real life. Following the alphabet (see next section) may help you here. Postoperatively, think of where the patient is going to be cared for, any ongoing need for oxygen or ventilatory support and how you will manage pain, nausea and thromboprophylaxis. Start to practise this systematic way of thinking in advance of every case you do, such that you could write a shopping list and recipe for any case you are involved in. It will help you when you get to the viva too.

Questions relating to particular patient conditions and their impact on anaesthetic management

You may get a question about a medical condition you have never learned about or really considered. You will all be familiar with using an ABC approach to patient assessment or ABCDE for trauma management. I have just taken that alphabet a little further.

A: airway
B: respiratory
C: cardiovascular
D: neurological, both central and peripheral (disability)
E: endocrine
F: pharmacology
G: gastrointestinal
H: haematology
I: immunology, infection
J: cutaneomusculoskeletal (joints)
K: renal (kidneys)
L: hepatic (liver)
M: metabolic
N: nutrition
O: obstetric
P: psychological

Following this alphabet will help you dredge the depths of your brain for issues that relate to diabetes, rheumatoid arthritis or epidermolysis bullosa. I promise you. Obviously, not all elements of the alphabet are relevant every time, but get into the habit of using it well in advance of the exam.

Finish the paper

If you miss out a question, you will fail (although you don't need to pass all questions in order to pass the paper overall). Do not allow yourself to run out of time. If you run over by 10 minutes

on a question you know well and are enjoying answering, you will find it very difficult to make up time elsewhere. You have 45 seconds for each mark.

One mark per line

The College have made it clear that you will not get more than one mark per line and so you are obliged to prioritise your answers. This reiterates the need to be specific in your approach rather than filling all the lines available with generic detail about how you would manage any anaesthetic or any emergency situation. The College have made it clear in their Reports that they want you to prioritise your answers so that they are as specific as possible to the question. Generic answers, even if true, may not get a mark.

Read the question

The Chairs' Reports will show you how often candidates run into difficulty for failing to read the question and they often say that all the information included in a question is there for a reason. Sometimes, two questions are asked within one section of a question – make sure you answer both bits. Abbreviations can cause confusion: ASD may mean autistic spectrum disorder or atrioseptal defect, but the College is always careful to specify what any abbreviation they use means. Another common error is failing to notice the change in the focus of a question. The first part may relate to children with autistic spectrum disorder, the second part may relate to management of any child for dental surgery, not just those with autistic spectrum disorder. Slow down and read carefully.

Abbreviations

Beware of using too many abbreviations yourself. Generally, if I have used an abbreviation, I define what I mean by it within that answer. Abbreviations that I have used without defining what they mean are listed in the front of the book and, I think, are commonly accepted.

Don't assume you don't know

Don't know the precise definition of cerebral palsy or autistic spectrum disorder? Visualise the people you have met affected by these conditions and describe them. Who: male, female, child, adult. When: lifelong, reversible, terminal. Why: genetic, infection related, trauma related. Keep calm and you will cobble together an answer that will gain you most of the marks available.

Improve your clinical knowledge

The Chairs' Reports have frequently commented on lack of knowledge impacting on answer quality. This is often clinical rather than book-based knowledge. It particularly affects subspecialties such as cardiothoracics and neurosurgery that not all candidates may have rotated through by the time they sit the exam. The College have advised that, currently (although this may change in the future), 6 of the 12 CRQs will be based on the mandatory units of training (neuro, cardiothoracics, intensive care medicine, paediatrics, pain medicine and obstetrics) with the rest from the other units. In the same way that a picture may be worth a thousand words, spending a day in cardiothoracic or neuro theatres will be invaluable. Trainees at my hospital have followed the College's advice and have arranged a couple of days' experience in these subspecialties and have found it very worthwhile. In the same way, you may need to be proactive in getting some

experience in vascular surgery, the interventional radiology suite and magnetic resonance imaging. Failing that, there's nothing you can't find on YouTube.

Remember that you don't need to get many marks to pass

Recent Chairs' Reports have said that each paper contains an even proportion of difficult, moderately difficult and easy questions. The recent Reports have not specified how many points are needed to pass a question, but older Reports have said that the pass mark for difficult questions is 10–11/20, for moderately difficult 12–13/20 and for easy 14/20. You can therefore miss out great chunks of what is present on the model answer and still pass! This exam is within your grasp.

Practise past questions

Practising past questions is a fantastic way to revise for a number of reasons. Question topics commonly recur: if you encounter a question you have previously practised, you will be able to answer it more quickly and with less brain fatigue, leaving you more time and energy for other questions. Looking at past questions helps you to develop technique. Also, you will get a feel for the topics that the College considers important by looking at what they have previously included in the exam.

This book

The topics of 24 past papers are covered in this book. This reflects 16 SAQ papers, seven CRQ papers and the hybrid one in between. The SAQ papers are published on the College website and we have adapted them in this book into CRQ style. The real CRQs are not published on the website, but the Chairs' Reports make it clear what the topics and some of the subsections were and we have created subsections based on what we think are important areas of knowledge. For each question, the relevant section of the Chairs' (or Chair's, before September 2015) Report is reproduced (where available), followed by our answers. We have included diagrams and additional commentary (in italics) to ensure that this book helps you to learn rather than just being a list of suggested model answers. We have no way of knowing how close our questions or answers are to the College's model answers, but they are referenced and represent a summary of the key topics that the College perceive as important. All have taken much more time to produce than you will have available to you in the exam and are answered much more extensively than the few words that the College wants from you in your answers (see the example CRQ model answers on the RCoA website). You must remember this when you are considering what level of detail of recall is required. You would not, therefore, need to write this level of detail in order to gain a pass in the exam.

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Dr Elizabeth Combeer

I would like to thank the supervisors and consultant bodies across Kent, Surrey, Sussex, South London and Wessex deaneries who have been integral to my training and development and who have made pursuing a career in anaesthesia extremely enjoyable. A special thanks is reserved for Dr Elizabeth Combeer, whose fierce dedication to education is an inspiration and without whom this second edition would not have been possible.

I am forever grateful to my parents and family for their unwavering support. Finally, thank you to my wife for making me smile when the depths of physiology, pharmacology and physics succeeded in achieving the opposite.

Dr Mitul Patel

1 ANAESTHESIA FOR NEUROSURGERY, NEURORADIOLOGY AND NEUROCRITICAL CARE

1.1 September 2011 Spinal cord injury

a) List the characteristic sensory, motor and autonomic neurological changes that occur immediately following transection of the spinal cord at the fourth thoracic vertebra. (3 marks)
b) List the characteristic sensory, motor and autonomic neurological changes that occur three months after transection of the spinal cord at the fourth thoracic vertebra. (3 marks)
c) State three ventilatory changes associated with complete transection of the spinal cord at the fourth thoracic vertebra. (3 marks)
d) List two gastrointestinal complications of spinal cord injury. (2 marks)
e) Give two reasons why patients with a recent spinal cord injury have an increased risk of thromboembolic disease. (2 marks)
f) Give one reason for poor body temperature regulation associated with spinal cord injury. (1 mark)
g) List four advantages of a regional anaesthetic technique for a cystoscopy in a patient with a previous spinal cord injury. (4 marks)
h) Why and when may suxamethonium be contraindicated in a patient with spinal cord injury? (2 marks)

The College likes this topic – it tests your neuroanaesthesia knowledge but also some primary anatomy and physiology. There was no Chair's Report for this paper.

a) List the characteristic sensory, motor and autonomic neurological changes that occur immediately following transection of the spinal cord at the fourth thoracic vertebra. (3 marks)

b) List the characteristic sensory, motor and autonomic neurological changes that occur three months after transection of the spinal cord at the fourth thoracic vertebra. (3 marks)

I have presented all the answers together in a table for revision purposes. There is more information here than would be necessary to achieve the total of six marks attributed to these two questions.

	Immediate	Changes at three months
Sensory	• Complete sensory loss below the T4 dermatome, extending cranially if there is secondary neurological injury e.g. oedema affecting the spinal cord.	• Ongoing anaesthesia below the T4 dermatome, extending proximally if secondary neurological injury present. • Development of neuropathic pain at or below the T4 dermatome. • Nociceptive pain may develop related to musculoskeletal injury caused by changes in function e.g. wheelchair use, muscle weakness and muscle spasm.

(Continued)

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(Continued)

	Immediate	Changes at three months
Motor	• Spinal shock: flaccid paralysis with areflexia affecting lower intercostals, trunk and lower limbs *(as even monosynaptic reflexes are dependent on descending tonic facilitation)*.	• Ongoing paralysis below the T4 dermatome (or more proximally if secondary neurological injury present). • Hyper-reflexia with spasticity. *Initially, upregulation of receptors facilitates reflexes, then new interneurones develop*.
Autonomic	• Hypotension (neurogenic shock) due to interruption of sympathetic pathways leaving unopposed parasympathetic activity. • If secondary injury extends cranially to affect cardioaccelerator fibres (T1–T4 segments), then bradycardia and reduced myocardial contractility occur, further worsening hypotension. • Loss of temperature control due to anhidrosis and cutaneous dilatation below T4 dermatome. • Loss of bowel and bladder function. • Occasionally, priapism may occur.	• Autonomic dysreflexia: non-noxious stimuli below the level of the lesion cause disproportionate reflex sympathetic output, resulting in lower body and splanchnic vasoconstriction increasing blood pressure. Life-threatening hypertensive crisis may occur *(with headache, flushing, nasal congestion, seizures, retinal haemorrhages, stroke and coma)*. Rising blood pressure stimulates (via baroreceptors) parasympathetic activity above the level of the lesion causing bradycardia and vasodilation, but this may be insufficient to reduce blood pressure to normal. The effect is worse in high cord lesions. Onset is variable, taking up to a year to develop. • Bowel, bladder and coital reflexes return but may remain impaired. Many patients require catheterisation.

c) State three ventilatory changes associated with complete transection of the spinal cord at the fourth thoracic vertebra. (3 marks)

The outcome is variable, as a patient with transection at T4 may have symptoms of a higher lesion due to secondary neurological injury.

- Loss of abdominal muscle contraction leads to weak forced expiration and impaired cough with retained secretions.
- Loss of innervation of lower intercostal muscles impairs the expansion of the chest wall and the vital capacity is reduced.
- Ventilation is worse in the sitting position. Abdominal contents pull down on the diaphragm, thus expanding expiratory intrathoracic volume and increasing residual volume. Volume for expansion in inspiration is therefore reduced and an increased proportion of minute ventilation therefore used on ventilating dead space, resulting in V/Q mismatch and atelectasis.
- Loss of abdominal wall and intercostal muscle tone results in inefficient ventilation: the diaphragm contracts, pushes abdominal contents down and out due to loss of abdominal wall tone and the chest wall is pulled in.

d) List two gastrointestinal complications of spinal cord injury. (2 marks)

- Reduced gastrointestinal motility: delayed gastric emptying (aspiration risk), paralytic ileus, constipation, pseudo-obstruction.
- Increased risk of gall stones and their complications *(thought to relate to altered motility of gastrointestinal structures causing slower transit of bile out of the gall bladder, altered enterohepatic circulation and metabolic changes causing altered bile lipids)*.
- Prone to stress ulceration due to unopposed vagal activity causing increased gastric acid production.

e) Give two reasons why patients with a recent spinal cord injury have an increased risk of thromboembolic disease. (2 marks)

The risk of death from pulmonary embolism is high in patients with spinal cord injury, contributed to by their increased risk of thromboembolic disease but also their inability to detect the limb changes that are associated with deep vein thrombosis which would prompt anticoagulant treatment. They are also at increased risk of ischaemic heart disease, partly due to their long-term prothrombotic state but also due to inability to undertake exercise. You will see that all three components of Virchow's triad are represented in the answer below.

- Immobility causing venous stasis.
- Loss of calf muscle pump activity causing venous stasis.
- Thrombogenic effect of the stress response of trauma.
- Inflammatory response of trauma causing endothelial damage.
- Use of venous lines.
- Associated surgery causing an increase in stress response.

f) Give one reason for poor body temperature regulation associated with spinal cord injury. (1 mark)

- Vasodilation below the level of spinal cord injury.
- Inability to sweat below the level of spinal cord injury *(risk of hyperhidrosis above the level of the injury)*.
- Inability to shiver below the level of the spinal cord injury.
- Loss of sensation of cold or hot environment below level of spinal cord injury.
- Loss of movement.
- Decrease in muscle bulk and reduced metabolic rate.

g) List four advantages of a regional anaesthetic technique for a cystoscopy in a patient with a previous spinal cord injury. (4 marks)

- Reduces the risk of autonomic dysreflexia.
- Avoids the need for intubation of a patient who may have previously had a tracheostomy with its attendant complications e.g. tracheal stenosis.
- Avoids the deterioration in lung function associated with general anaesthesia, thus reducing the risk of postoperative respiratory complications.
- Avoids opioid use with associated respiratory depression in a patient with compromised respiratory function.
- Reduces the risk of aspiration associated with delayed gastric emptying.
- Avoidance of unopposed parasympathetic response to airway instrumentation (bradycardia, cardiac arrest).

h) Why and when may suxamethonium be contraindicated in a patient with spinal cord injury? (2 marks)

- Upregulation of nicotinic acetylcholine receptors in extrajunctional sites results in massive potassium release with suxamethonium use.
- This effect is seen between approximately 72 hours following injury and six months.

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1.2 September 2012 Raised intracranial pressure

a) State three symptoms of raised intracranial pressure (ICP) in an adult. (3 marks)
b) Describe three signs of raised ICP in an adult. (3 marks)
c) Give the upper limit (mmHg) of normal ICP in an adult. (1 mark)
d) List two invasive monitoring methods of ICP in a patient with traumatic brain injury. (2 marks)
e) List eight management goals that may be undertaken in the Emergency Department of a non-neurosurgical centre to initiate optimal treatment of a patient with traumatic brain injury. (8 marks)
f) Give two pharmacological options, with doses, that may be used to treat acute rises in intracranial pressure whilst preparing for definitive neurosurgical intervention. (2 marks)
g) Give one other temporising measure for management of acute rises in intracranial pressure. (1 mark)

The Chair's Report of the original SAQ commented that many candidates misread one of the subsections and the pass rate for the question was 56%. This is a common topic in the written exam, the viva and real life and should be one that you are comfortable with answering.

a) State three symptoms of raised intracranial pressure (ICP) in an adult. (3 marks)

- Headache: bursting, throbbing *(exacerbated by sneezing, exertion, recumbency, and the raised $PaCO_2$ associated with sleep)*.
- Vomiting *(often accompanies the headache and so tends to be worse in the morning after waking)*.
- Visual disturbance.

b) Describe three signs of raised ICP in an adult. (3 marks)

- Progressive reduction in consciousness due to caudal displacement of midbrain.
- Eye signs including papilloedema, fundal haemorrhages, pupillary dilatation, ptosis, impaired upward gaze (midbrain compression), and abducens palsy.
- Motor features including ataxia, abnormal posturing, focal neurological deficit, and seizure activity.
- Respiratory irregularity, Cheyne-Stokes breathing, neurogenic hyperventilation due to tonsillar herniation.
- Cushing's triad of hypertension with high pulse pressure, bradycardia, and associated irregular respiration *(indicative of brainstem ischaemia associated with herniation)*.

c) Give the upper limit (mmHg) of normal ICP in an adult. (1 mark)

- 15 mmHg.

d) List two invasive monitoring methods of ICP in a patient with traumatic brain injury. (2 marks)

- Intraventricular catheter *(also referred to as an external ventricular drain – can be calibrated and can be used to therapeutically drain CSF)*.
- Transducer pressure monitoring in subdural, intraparenchymal, subarachnoid or epidural space. *(Transducer may be a balloon, strain gauge, or fibreoptic tip. Once it is sited, there is no ability to recalibrate it. May not reflect variation of intracranial pressure in different parts of brain.)*

e) List eight management goals that may be undertaken in the Emergency Department of a non-neurosurgical centre to initiate optimal treatment of a patient with traumatic brain injury. (8 marks)

According to the Monro-Kellie doctrine, the cranium is a closed compartment and so has a fixed capacity. If there is an increase in one component of its contents (brain, CSF, blood in blood vessels, other) some compensation can occur by reducing the amount of one of the other components. Once these compensatory mechanisms are exhausted, ICP will rise, ultimately causing pressure on the brain and direct tissue damage. This typically occurs > 20 mmHg (the Brain Trauma Foundation guidelines advise initiating treatment > 22 mmHg to prevent mortality). As ICP rises, the cerebral perfusion pressure will decrease according to the equation:

$$CPP = MAP - ICP$$

This will cause ischaemic brain damage. Successful initial management of a brain injured patient help to manipulate the size of the components in the closed box and reduce the risk of secondary brain injury. In real life, or a question with a different approach, don't forget that this patient may have a cervical spine injury too.

- Tracheal intubation if GCS ≤ 8, if not maintaining adequate gas exchange, has lost protective laryngeal reflexes, is spontaneously hyperventilating, or has irregular respirations.
- Avoid hypoxia, aim PaO_2 > 13 kPa.
- Maintain $PaCO_2$ between 4.5 and 5.0 kPa.
- Maintain MAP > 80 mmHg replacing lost volume with non-hypotonic fluid, blood if indicated, and using vasopressor if required.
- Adequate sedation (and analgesia) to reduce $CMRO_2$.
- Muscle paralysis if needed to facilitate ventilation to desired PaO_2 and $PaCO_2$ and if patient not synchronising with ventilator.
- Facilitate venous drainage by 30–45 degree head-up tilt, avoidance of tight tube ties, avoidance of PEEP > 12 cmH_2O or high peak airway pressures while ensuring adequate gas exchange and adopting a lung protective strategy (*higher airway pressures may later be used if monitoring shows ICP remains normal and is PEEP insensitive*).
- Treatment of seizures.
- Maintenance of normoglycaemia, < 10 mmol/l.
- Maintenance of normothermia.
- Discuss with regional neurosurgical unit to arrange early transfer.

f) Give two pharmacological options, with doses, that may be used to treat acute rises in intracranial pressure whilst preparing for definitive neurosurgical intervention. (2 marks)

- Mannitol 0.25–1 g/kg.
- Hypertonic saline 3% 2 ml/kg.

g) Give one other temporising measure for management of acute rises in intracranial pressure. (1 mark)

- Hyperventilation to a $PaCO_2$ of 4–4.5 kPa.

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1.3 March 2013 Acromegaly and trans-sphenoidal hypophysectomy

A 45-year-old male with acromegaly presents for an elective trans-sphenoidal hypophysectomy.

a) What is the cause of acromegaly in this patient? (1 mark)
b) Where is the pituitary gland located? (1 mark)
c) State the visual impairment characteristically associated with a large pituitary tumour. (1 mark)
d) Describe the blood supply to the pituitary gland. (2 marks)
e) List two hormones secreted by the posterior pituitary gland. (2 marks)
f) List six clinical features of acromegaly of relevance to the anaesthetist. (6 marks)
g) How do the surgical requirements for this procedure influence the conduct of the anaesthesia? (4 marks)
h) State three specific complications of trans-sphenoidal hypophysectomy. (3 marks)

The SAQ on this topic had a 57% pass rate, but the Chair's Report suggested "that many candidates had not had experience of managing these patients for this type of surgery. Some candidates quoted the prone position for surgical access!"

a) What is the likely cause of acromegaly in this patient? (1 mark)

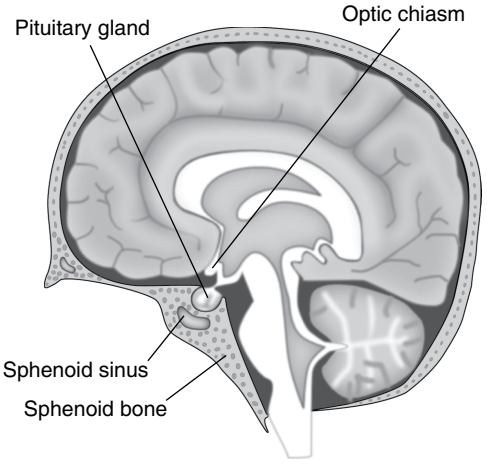
Adenomas can be microadenomas or macroadenomas: macroadenomas may also present with raised ICP or visual field defects (bitemporal hemianopia). Rarely, growth hormone can be secreted from non-pituitary tumours – but these patients would not be having a trans-sphenoidal resection.

- Hypersecretion of growth hormone from a pituitary adenoma.

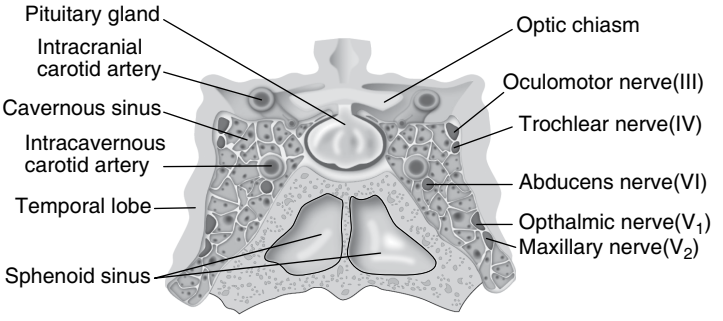
b) Where is the pituitary gland located? (1 mark)

- Sits in the sella turcica, which is the part of the sphenoid bone.

A little bit of revision about the anatomy and function of the pituitary (as I don't want you to be one of the people who think that it is best accessed from the back of the head).



Sagittal section of the pituitary gland.



Coronal section of the pituitary gland.

c) State the visual impairment characteristically associated with a large pituitary tumour. (1 mark)

- Bitemporal hemianopia.

d) Describe the blood supply to the pituitary gland. (2 marks)

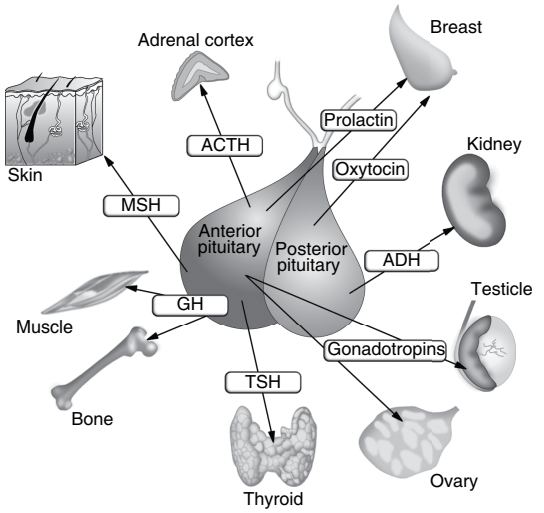
- The pituitary receives arterial supply from the hypophyseal and inferior hypophyseal arteries, which are branches of the internal carotid artery.
- The arteries anastomose with each other to form vascular plexuses around the gland and a portal circulation which connects to the dural venous sinuses and the hypothalamus.
- Venous drainage is into the cavernous and petrosal sinuses.

e) List two hormones secreted by the posterior pituitary. (2 marks)

- Anti-diuretic hormone (ADH)/vasopressin.
- Oxytocin.

Adenohypophysis or anterior pituitary: hypothalamus releases inhibitory or secretory factors, which travel via the portal system to the anterior pituitary, where they control the release of the anterior pituitary hormones.

Neurohypophysis or posterior pituitary: neurosecretory cells in the hypothalamus make oxytocin and vasopressin, which travel down axons to be released from the posterior pituitary.



Key:	
ACTH	Adrenocorticotrophic hormone
ADH	Antidiuretic hormone, vasopressin
GH	Growth hormone
MSH	Melanocyte stimulating hormone
TSH	Thyroid stimulating hormone

Pituitary gland hormones.

f) List six clinical features of acromegaly of relevance to the anaesthetist. (6 marks)

Now you are being asked about the features of acromegaly generally. Back to the alphabet.

Airway:

- Large lips, macroglossia, macrognathia, thickening of pharyngeal tissues, laryngeal stenosis. Possibility of difficult airway should be considered.

Respiratory:

- Obstructive sleep apnoea (OSA) with risk of hypoventilation and respiratory failure postoperatively.

Cardiovascular:

- Hypertension, left ventricular hypertrophy, cardiomyopathy with diastolic dysfunction, valvular regurgitation, ECG changes.
- Increased peripheral soft tissue deposition may make cannulation difficult.

Neurological:

- Raised ICP (obstruction of the third ventricle).
- Spinal cord compression. Meticulous care with padding and positioning required.
- Peripheral neuropathies due to impingement by soft tissue or bony overgrowth.

Endocrine:

- Diabetes mellitus. Blood glucose should be monitored and managed with insulin intraoperatively if necessary.

Gastrointestinal:

- Increased risk of colonic polyps and cancer – may necessitate surgery.

Cutaneomusculoskeletal:

- Osteoarthritis, bony overgrowth around joints, limited movement. Care with positioning and padding.

Renal:

- Renal dysfunction may impact on perioperative drug choices.

g) How do the surgical requirements for this procedure influence the conduct of the anaesthesia? (4 marks)

Even if you have never seen this operation before, you know something about the logistics of anaesthesia where the patient's head is distant from the anaesthetist from doing ENT surgery.

Surgical requirement	Conduct of anaesthesia
Use of operating microscope.	"Hypotensive" anaesthesia, intra-arterial monitoring, immobile patient (muscle relaxant or remifentanil infusion). Preparation of nasal mucosa with e.g. Moffat's solution or phenylephrine.
Periods of intense stimulation and periods of minimal stimulation.	Blood pressure may be very labile, necessitating intra-arterial monitoring. Remifentanil is ideal for management of periods of intense stimulation.
Supine position with head-up tilt.	Potential for air embolism. Ensure adequate intravenous filling.

(Continued)

(Continued)

Surgical requirement	Conduct of anaesthesia
Operation on head.	Airway under drapes, armoured tube, anaesthetist distant from airway, meticulous securing of tube, protection of eyes, nerve stimulator on leg, circuit extensions for breathing system and for intravenous fluids.
Risk of bleeding from internal carotid or cavernous sinus.	Intubate (anticipate difficult airway), throat pack, two group and save samples preoperatively.
Rapid emergence, need ability to assess neurology as soon as possible postoperatively.	Use of short-acting and rapidly reversible agents.
Suprasellar portion of tumour may need pushing into surgical field.	Lumbar drain with injection of saline or, less commonly, controlled ventilation to ensure high-normal $PaCO_2$.
Avoid postoperative surges in ICP, especially if CSF leak has occurred.	Smooth emergence, adequate reversal, adequate antiemetic, airway and CPAP for known OSA.

h) State three specific complications of trans-sphenoidal hypophysectomy. (3 marks)

- Surgical damage to anatomically related structures:
  - Cranial nerve III, IV, V, or VI palsy.
  - Visual field defects (proximity of optic chiasm).
  - Major haemorrhage.
  - CSF leak.
- Postoperative endocrine dysfunction:
  - Diabetes insipidus – may resolve spontaneously.
  - SIADH.
  - Hypopituitarism – steroid replacement with weaning regimen may be required.
- Pituitary apoplexy.
- Venous air embolus (rare, but theoretically possible due to sitting position).

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1.4 September 2013 Posterior fossa surgery

A 34-year-old man is scheduled for a posterior fossa tumour excision.

a) Apart from the sitting position, give three patient positions that might be employed for this operation. (3 marks)
b) Venous air embolism is a complication of the sitting position. Give four other specific complications of the sitting position. (4 marks)
c) Give three abnormalities in routine intraoperative monitoring which may develop as a consequence of venous air embolism. (3 marks)
d) List three different monitoring techniques that can specifically detect the presence of venous air embolism during surgery and the features that would indicate the diagnosis for each monitor. (6 marks)
e) After calling for help and assessing the patient in a systematic manner, list four steps that can be undertaken to manage a significant venous air embolism in this patient. (4 marks)

The Chair's Report of the original SAQ stated that inexperience in anaesthesia for this type of surgery was apparent, with a 48.4% pass rate. This may be a type of surgery you do not see by the time of sitting your exam. However, the line of questioning about posterior fossa surgery, in either the written exam or the viva, will usually focus on the risks of positioning and diagnosis and management of venous air embolus, all of which are covered here.

a) Apart from the sitting position, give three patient positions that might be employed for this operation. (3 marks)

Search for images of the different positions for neurosurgery. It will really help you to retain the information about their associated complications. The sitting position is associated with significant risk but is good for access to midline lesions. Gravity assists venous and CSF drainage, thus improving the surgical field and facilitating access to deeper structures.

- Supine with head turned, supported by sandbags *(may be suitable for acoustic neuroma or cerebellopontine angle tumours).*
- Prone *(as with the sitting position, this offers good access for midline structures).*
- Lateral *(good access for lateral structures).*
- Park bench *(modification of the lateral position with the patient semi-prone, head flexed to face the floor, offering greater access to the midline, avoiding the need for sitting or prone positioning).*

b) Venous air embolism is a complication of the sitting position. Give four other specific complications of the sitting position. (4 marks)

These are all individual complications but have been grouped by body system to help you memorise them.

Airway:

- Endotracheal tube displacement.
- Jugular venous obstruction due to flexed neck causing laryngeal and tongue oedema with postoperative airway compromise.

Cardiovascular:

- Hypotension due to reduced venous return due to venous pooling in dependent areas.

Neurological:

- Cord or brainstem ischaemia due to head flexion and hypotension.
- Sciatic and femoral nerve damage from excessive hip flexion compounded by lower limb oedema due to dependent positioning.
- Pneumocephalus (delayed recovery, neurological deficit, confusion, headache).

Cutaneomusculoskeletal:

- Compartment syndrome.
- Lumbosacral pressure damage.

c) Give three abnormalities in routine intraoperative monitoring which may develop as a consequence of venous air embolism. (3 marks)

- Drop in SpO_2.
- Decrease in $etCO_2$.
- ST segment depression on ECG monitoring.
- Tachyarrhythmia.
- Hypotension.

d) List three different monitoring techniques that can specifically detect the presence of venous air embolism during surgery and the features that would indicate the diagnosis for each monitor. (6 marks)

In practice, precordial Doppler is used alongside gas exchange, invasive arterial and possibly central venous monitoring and, just as importantly, clinical suspicion.

Precordial Doppler:	Sound heard if air present in cardiac chambers *(this is the most sensitive noninvasive device).*
Transoesophageal echocardiography:	Air seen in right-sided cardiac chambers. *(In the presence of patent foramen ovale, it can detect air in the left heart also. Not necessarily suitable for long operations where the head is flexed.)*
Pulmonary artery or right atrial pressure:	Pulmonary artery pressure will rise with a significant air embolus and related right ventricular outflow tract obstruction can cause rise in right atrial pressure. *(Not routinely indicated for this purpose.)*
Oesophageal stethoscope:	"Mill wheel murmur". *(A large volume of air is required to cause the noise, at which point cardiovascular collapse may have occurred.)*
End-tidal nitrogen level:	Sudden rise in end-tidal nitrogen due to presence of nitrogen in the air embolus. *(More sensitive and specific for VAE than $etCO_2$ changes but not readily available.)*

e) After calling for help and assessing the patient in a systematic manner, list four steps that can be undertaken to manage a significant venous air embolism in this patient. (4 marks)

Each of the following is a separate step, but they have been grouped in order to assist with learning.

- Prevent further air entry:
  - Ask surgeon to flood site with saline and cover with wet packs.
  - Administer fluids especially if hypovolaemia thought to be contributory to air entrainment.
  - Lower the head of patient so that the surgical site is below the right atrium if possible.
  - Apply sustained positive airway pressure until these measures have been achieved.
- Reduce size of air embolism:
  - Administer 100% oxygen.
  - Stop nitrous oxide if it is being used.
  - Aspirate air from right atrium via central line if one is present.

- Overcome mechanical obstruction:
  - Left lateral or Trendelenburg positioning may help force bubble above the right ventricular outflow.
  - If the patient suffers cardiac arrest or severe haemodynamic compromise, chest compressions may assist in dispersing the bubble.
  - Inotropic support may be required.

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1.5 March 2014 Stereotactic brain biopsy

A 64-year-old man is scheduled for a stereotactic brain biopsy. He is taking dual antiplatelet therapy (DAPT) following the insertion of a drug-eluting coronary artery stent six months previously.

a) Give three possible consequences of continuing antiplatelet medication in the perioperative period. (3 marks)
b) Give two possible consequences of premature cessation of DAPT in order to facilitate brain biopsy in this patient. (2 marks)
c) List four patient factors that will increase the risk of an ischaemic event following premature cessation of DAPT in this patient. (4 marks)
d) Give three approaches that may mitigate patient risk if a decision is made to stop DAPT in order to facilitate the stereotactic brain biopsy. (3 marks)
e) List four specific contraindications to stereotactic brain biopsy under sedation. (4 marks)
f) List four specific complications of stereotactic brain biopsy under sedation. (4 marks)

The Chair's Report following the original SAQ commented that "candidates misread or misinterpreted the question [and] did not appreciate that the management of antiplatelet therapy requires a balance of risks in a patient for whom intraoperative bleeding could be a critical event. Many candidates mentioned stent thrombosis and intracranial/extracranial haemorrhage but did not explain why these events would be important even though the question specifically asks for these details." The pass rate was 32.9%.

a) Give three possible consequences of continuing antiplatelet medication in the perioperative period. (3 marks)

- Significant extracranial bleeding.
- Intraparenchymal haemorrhage with limited ability to access the source and therefore control it.
- Haematoma development with pressure effect on brain resulting in specific neurological deficits or raised intracranial pressure.

b) Give two possible consequences of premature cessation of DAPT in order to facilitate brain biopsy in this patient. (2 marks)

- Risk of stent thrombosis which carries a high mortality risk.
- Risk of myocardial infarction or ischaemia as a consequence of pre-existing coronary artery disease.
- Rebound increase in tendency to thrombosis following cessation of ADP receptor antagonist.

c) List four patient factors that will increase the risk of an ischaemic event following premature cessation of DAPT in this patient. (4 marks)

- Cigarette smoking.
- Diabetes mellitus.
- Congestive heart failure/LVEF < 30%.
- Having had PCI prior to the PCI six months previously.
- Previous MI.
- MI as the indication for PCI and DES.

d) Give three approaches that may mitigate patient risk if a decision is made to stop DAPT in order to facilitate the stereotactic brain biopsy. (3 marks)

- Perform brain biopsy in a centre with on-site 24-hour interventional cardiology support to attempt to mitigate the severity of any thrombosis that occurs.
- Consideration of bridging with a short-acting GP IIb/IIIa inhibitor, starting within 24 hours of stopping ADP receptor blocker.
- Consideration of bridging with short acting, reversible $P2Y_{12}$ receptor antagonist, cangrelor.
- Consideration of continuing aspirin in the perioperative period if high risk of stent thrombosis and neurosurgeon deems the biopsy low risk for bleeding.

e) List four possible specific contraindications to stereotactic brain biopsy under sedation. (4 marks)

- Patient unable to comply with instruction e.g. learning disability, dementia, poor hearing.
- Patient refusal.
- Patient movement disorder, inability to lie still, inability to lie flat.
- Chronic cough.
- Significant sleep apnoea.
- Difficult airway.
- Patient anxiety or claustrophobia.

f) List four specific complications of stereotactic brain biopsy under sedation. (4 marks)

- Loss of airway and difficulties with access due to the use of a frame.
- Patient obtundation and therefore rise in $PaCO_2$ and decrease in PaO_2, which may cause increase in intracranial pressure and potential implications for the biopsy.
- Patient movement making biopsy not feasible or causing complications.
- Patient pain due to inadequate topicalisation of scalp or inadequate analgesia.
- Risk of nausea and vomiting due to e.g. opioid analgesia, stress.

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1.6 March 2015 Raised intracranial pressure

A 54-year-old patient is admitted to the emergency department following a traumatic brain injury. A CT scan reveals only cerebral oedema.

a) What is secondary brain injury and when is it likely to occur? (2 marks)
b) Outline four physiological and cellular changes associated with secondary brain injury. (4 marks)
c) List four indications for immediate intubation of this patient. (4 marks)
d) Give three respiratory goals for minimising the risk of secondary brain injury in this patient. (3 marks)
e) Give two cardiovascular goals for minimising the risk of secondary brain injury in this patient. (2 marks)
f) Give three other measures undertaken to minimise the risk of secondary brain injury in this patient. (3 marks)
g) Give two methods of managing acute rises in intracranial pressure whilst awaiting transfer to a neurosurgical centre. (2 marks)

The Chair's Report of the original SAQ commented that the 8.3% pass rate was "disturbing". They said, "Management of head injury not requiring neurosurgery is common to most intensive care units. Many candidates were unable to define secondary injury or give an appropriate time frame. Most were unaware of the pathophysiological cellular mechanisms and focused solely on the Monro-Kellie doctrine. Overall knowledge of NICE guidelines was superficial and most candidates did not define the physiological goals for therapy in enough detail. Treatment options were too narrow in scope although the information given was usually sensible. Examiners were left with the overall impression that many candidates have little theoretical knowledge or practical experience of care of the brain injured patient."

a) What is secondary brain injury and when is it likely to occur? (2 marks)

Primary brain injury occurs due to the initial insult and depends on the nature, intensity, and duration of impact. Macroscopically, it may involve fracture, contusion, haematoma, cerebral oedema, and diffuse brain injury. Microscopically it will involve cell wall disruption and increased membrane permeability disrupting ionic haemostasis.

- Primary brain injury causes a series of metabolic, inflammatory and vascular processes that may lead to secondary tissue damage beyond the initial injury site over the subsequent hours to days. It may be mediated by cerebral oedema, localised tissue hypoxia, excitotoxicity, or metabolic dysfunction. Additionally, systemic complications of traumatic brain injury may result in cardiovascular dysfunction causing further damage due to cerebral hypoperfusion and hypoxia.

b) Outline four physiological and cellular changes associated with secondary brain injury. (4 marks)

- Raised intracranial pressure in association with systemic hypotension may cause reduced cerebral perfusion pressure which can result in cerebral hypoperfusion with tissue ischaemia and inadequate substrate delivery.
- Local tissue damage causes excessive release of excitatory neurotransmitters (excitotoxicity), resulting in calcium influx to cells, cell oedema, and death.
- Injured cells release inflammatory mediators (platelet activating factor, leukotrienes, reactive oxygen species) that affect the blood brain barrier and increase blood vessel permeability, resulting in vasogenic oedema, raising ICP further.
- Impaired cell membrane function leads to accumulation of intracellular water and cytotoxic oedema. This increases intracerebral pressure and worsens tissue perfusion causing worsening injury.

- Impaired cerebral autoregulation may cause increased cerebral blood flow and vasogenic oedema with subsequent raised ICP.
- Hypoxia, hypotension, hyper- or hypocapnia and hyper- or hypoglycaemia will exacerbate secondary brain injury, worsen ability to autoregulate, cause direct changes to brain tissue size and therefore impact on ICP and perfusion, thus perpetuating a downward vicious cycle.
- Seizures will cause a significant increase in cerebral metabolism leading to ischaemia, cellular dysfunction and increased ICP. Generalised tonic-clonic seizures will also raise metabolic rate and, if ventilation is not increased, lead to raised $PaCO_2$ causing further increases in ICP.

c) List four indications for immediate intubation of this patient. (4 marks)

The information required for these next subsections is similar to that required in the question from September 2012. This answer is based on NICE CG176, which was originally published in 2014 and then featured in the exam a year later. However, even if you haven't read the guidance, I believe that anyone who has managed brain injured patients in the emergency department should know this answer.

- Coma, GCS ≤ 8.
- Loss or impairment of laryngeal reflexes.
- Ventilatory insufficiency (PaO_2 < 13 kPa, $PaCO_2$ > 6 kPa).
- Spontaneous hyperventilation causing $PaCO_2$ < 4 kPa.
- Irregular respirations.

d) Give three respiratory goals for minimising the risk of secondary brain injury in this patient. (3 marks)

- Target PaO_2 greater than 13 kPa.
- Target $PaCO_2$ 4.5–5.0 kPa.
- Avoiding excessive PEEP (aim < 12 cmH_2O) and high mean airway pressures whilst maintaining adequate ventilation and ensuring lung protective strategy.

e) Give two cardiovascular goals for minimising the risk of secondary brain injury in this patient. (2 marks)

- Maintain MAP > 80 mmHg replacing lost volume with non-hypotonic fluid, blood if indicated, and using vasopressor if needed.
- Facilitate venous drainage by 30–45 degree head-up tilt, avoidance of tight tube ties, avoidance of excessive PEEP or mean airway pressures (while ensuring adequate gas exchange and adopting a lung protective strategy), use of NMBD if coughing or straining on tube.

f) Give three other measures undertaken to minimise the risk of secondary brain injury in this patient. (3 marks)

Different guidelines have given slightly different target ranges for glycaemic control over the years depending on the evidence they have referenced, which depends on precisely how those studies were structured and what the limits of the control and intervention arms of the studies were. It currently seems that the target for any patient with a compromised brain should be < 10 mmol/l whilst avoiding hypoglycaemia. Very tight blood glucose control is associated with hypoglycaemic episodes, which are damaging to the already compromised brain.

- Adequate sedation (and analgesia) to reduce $CMRO_2$.
- Treatment of seizures.
- Maintenance of normoglycaemia, < 10 mmol/l.
- Maintenance of normothermia.
- Muscle paralysis if needed to facilitate ventilation to desired PaO_2 and $PaCO_2$ and if patient not synchronising with ventilator.

g) Give two methods of managing acute rises in intracranial pressure whilst awaiting transfer to a neurosurgical centre. (2 marks)

- Hyperventilation to a $PaCO_2$ of 4–4.5 kPa.
- Osmotherapy with mannitol 0.25–1 g/kg.
- Osmotherapy with hypertonic saline 3% 2 ml/kg.

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1.7 September 2015 Spinal cord injury

A 19-year-old patient has suffered a complete transection of the spinal cord at the first thoracic vertebral level due to a fall but has no other injuries.

a) Outline the sequence of neurological effects that may develop in the first three months following injury. (6 marks)
b) Which disturbances of the cardiovascular, respiratory and gastrointestinal systems may subsequently occur? (8 marks)
c) When and why may suxamethonium be contraindicated in this patient? (2 marks)
d) Give the advantages of a regional anaesthetic technique for a patient having elective lower limb surgery two years after a high thoracic spine transection. (4 marks)

As this is a repeated topic, I have reproduced the SAQ here in its original format. The Chairs' Report stated that "This question had the highest correlation with overall performance; i.e. candidates who did well in this question performed well overall in the SAQ. The examiners commented that part (d), about the advantages of regional anaesthesia for elective lower limb surgery, was not well answered. Candidates tended to give general answers such as 'avoids the need for general anaesthesia' or 'maintains cardiovascular stability' rather than specific advantages such as 'reduces the risk of autonomic dysreflexia' or 'avoids postoperative respiratory inadequacy due to general anaesthesia.'" The pass rate was 49.4%. The knowledge required for this question is the same as that required for the question on spinal cord injury in September 2011. If candidates had prepared themselves by addressing the topics covered in past papers, more than half would have passed.

1.8 March 2016 Acromegaly and trans-sphenoidal hypophysectomy

A 54-year-old male with acromegaly presents for a trans-sphenoidal hypophysectomy.

a) What is acromegaly? (2 marks)
b) List the clinical features of acromegaly which are of relevance to the anaesthetist. (8 marks)
c) What other clinical presentations of a pituitary adenoma may be encountered? (2 marks)
d) What specific considerations, including surgical factors, may influence the conduct of anaesthesia in this patient? (8 marks)

Another repeated topic and so the SAQ is reproduced as it appeared in the exam. The Chairs' Report said that "this question was answered well despite it having been adjudged to be hard. However, few candidates either knew that acromegaly was a multisystem disease or could list the other possible clinical presentations of a pituitary adenoma e.g. mass effects. Candidates who performed poorly in part (d) failed to describe the specific issues when anaesthetising a patient for this procedure and focused more on general neuroanaesthetic principles. This is a common mistake that has occurred in many questions across many exams. This question also correlated well with overall performance." The pass rate was 58.8%. A score of only 10–11/20 was required to pass this "hard" question. It was very similar to that from March 2013 with only parts (a) and (c) being different and so answers to those parts are given below for the sake of learning.

a) What is acromegaly? (2 marks)

- Acromegaly is the condition that results from excessive growth hormone secretion after the growth plates have fused.
- In this patient and 90% of cases, it results from hypersecretion from a pituitary adenoma.
- Occasionally, it may result from an ectopic pituitary adenoma near, but not in, the sella turcica.
- Rarely, it results from secretion of growth hormone releasing hormone or growth hormone by lung, pancreatic or adrenal tumours.

c) What other clinical presentations of a pituitary adenoma may be encountered? (2 marks)

Non-secretory presentation:

- Local pressure effects causing visual disturbance (bitemporal hemianopia), headache.
- Raised intracranial pressure, cranial nerve palsies, and hydrocephalus due to third ventricle outflow blockage.

Hypersecretory presentation:

- Cushing's disease; hypersecretion of adrenocorticotrophic hormone (ACTH) resulting in fatigue, truncal obesity, striae, moon face, buffalo hump, hypertension, glucose intolerance, depression, anxiety.
- Hyperpituitarism; hypersecretion of any or all anterior pituitary hormones.

Hyposecretory presentation:

- Pituitary apoplexy; internal haemorrhage of the adenoma, or when the adenoma outgrows its blood supply, causing tissue necrosis and swelling. There is consequent loss of anterior pituitary hormones. Symptoms include visual loss, sudden-onset headache, cardiovascular instability.
- Central diabetes insipidus; a macroadenoma may cause damage to posterior pituitary blood supply, thus (rarely) causing diabetes insipidus with polyuria and polydipsia.

- Pituitary-related hypothyroidism; generally less severe than hypothyroidism of thyroid origin.
- Adrenocortical insufficiency; again, not as severe as adrenocortical insufficiency of adrenal origin.

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1.9 September 2016 Guillain-Barré syndrome

a) What is Guillain-Barré syndrome (GBS)? (1 mark)
b) State the underlying pathophysiology of GBS. (1 mark)
c) List two possible triggers for GBS. (2 marks)
d) List four clinical features of GBS. (4 marks)
e) List three investigations that may be used to support the diagnosis and the findings for each which may indicate GBS. (6 marks)
f) List six specific considerations when anaesthetising a patient recovering from GBS. (6 marks)

The Chairs' Report of the SAQ on this topic stated that it "was surprisingly poorly answered, with some candidates becoming confused between Guillain-Barré syndrome and myasthenia gravis . . . some candidates lost marks by not mentioning the findings of investigations . . . [and] answered with regard to general principles of intraoperative management of a critically ill patient, rather than the measures specific to a patient recovering from GBS." The pass rate was 53.3%.

a) What is Guillain-Barré syndrome (GBS)? (1 mark)

Don't get your neurological disorders all mixed up – there are two great BJA Education articles that succinctly summarise the different disorders and their main implications for anaesthesia.

- Acute, immune-mediated, pre-junctional, ascending demyelinating (most commonly) polyneuropathy affecting sensory, motor, and autonomic nerves.

b) State the underlying pathophysiology of GBS. (1 mark)

GBS is also called acute inflammatory demyelinating polyradiculoneuropathy, ADIP, but this is only the most common subtype – there are a variety of clinical presentations and a more severe disease course with less certain recovery is caused by damage to the axons themselves instead of the myelin sheath.

- Autoantibody damage to myelin sheath or, less commonly, axon of nerves (associated with antiganglioside or other anti-glycolipid antibodies).

c) List two possible triggers for GBS. (2 marks)

- Gastrointestinal (especially campylobacter) or respiratory infection, which may be bacterial, viral (influenza, COVID-19, Zika, CMV, EBV, HIV), or protozoal.
- Vaccination.

d) List four clinical features of GBS. (4 marks)

Whenever you are describing a neurological condition, be clear in your mind whether it is upper or lower motor neurone; whether it affects motor, sensory or autonomic nerves; and whether the defect is of the axon, myelin sheath or neuromuscular junction. The presentation is variable depending upon the subtype.

- Acute onset of symptoms and signs. Recovery is variable, ranging from full recovery to prolonged disability, to relapsing and remitting form.
- Motor features: typically ascending symmetrical weakness (flaccid, areflexic paralysis), may ascend to involve respiratory muscles causing respiratory failure and also to cause facial nerve palsies with bulbar weakness and ophthalmoplegia.
- Sensory features: ascending sensory impairment associated with pain and paraesthesia.
- Autonomic features: arrhythmias, labile BP, urinary retention, paralytic ileus, hyperhidrosis, sudden death.
- Miller Fisher syndrome: this variant is typified by ataxia, areflexia, ophthalmoplegia +/– respiratory and limb weakness.

e) List three investigations that may be used to support the diagnosis and the findings for each which may indicate GBS. (6 marks)

Blood tests are routinely performed for any critically ill patient. You may see alterations reflective of the trigger cause and possibly raised ESR and CRP. Serology for known trigger pathogens may also be seen. The patient may have a positive stool culture for campylobacter. An ABG may show the development of respiratory failure and respiratory function tests will show why. A CT brain should be checked to rule out other causes. However, the tests that I would list here are the ones that have greater specificity for GBS.

- MRI of the spine: selective anterior spinal nerve root enhancement with gadolinium.
- Lumbar puncture: normal cell count and glucose, elevated protein levels (although even this may be normal early in the disease).
- Nerve conduction studies: depends on the subtype, the majority show demyelinating pattern (reduction in conduction velocity), some show axonal loss (reduction in compound action potential size).
- Antiganglioside (otherwise called antiglycolipid) antibodies may be positive especially if an axonal variant.

f) List six specific considerations when anaesthetising a patient recovering from GBS. (6 marks)

Back to the alphabet to help organise your thoughts. Pick the ones that are most important to get your 6 marks.

Airway:

- Bulbar weakness, poor cough, increased risk of aspiration. Intubation required – consider need for rapid sequence induction.
- May still have tracheostomy in situ if still requiring ventilatory support or assistance with secretion clearance.

Respiratory:

- Increased risk of pneumonia secondary to aspiration and poor ventilatory function. Make full assessment of this – history, nature of secretions, temperature, chest auscultation. Treat as required, delay non-urgent surgery if necessary.
- Significantly reduced ventilatory capacity, assess likelihood of requiring noninvasive or invasive ventilation postoperatively.

Cardiovascular:

- Autonomic instability, labile BP (with sensitivity to commonly used vasoactive drugs), risk of arrhythmia. Invasive monitoring indicated including cardiac output monitoring to guide fluid administration (ensure full circulation as dehydration will exacerbate lability).
- Prolonged illness with multiple cannulations, access may be tricky.

Neurological:

- Neuropathic pain common – may already be on antineuropathic drugs +/− opioid analgesia. Need to plan postoperative pain relief, involve acute pain team.

Pharmacology:

- Suxamethonium: contraindicated due to risk of hyperkalaemia due to upregulation of extrajunctional nicotinic receptors.
- Non-depolarising neuromuscular blocking drugs: increased sensitivity, prolonged paralysis may result, reduced dose should be used.

- Opioids: increased sensitivity to respiratory depressant effect in the presence of existing respiratory compromise, may already be taking opioids and so dose adjustments may be necessary.

Haematology:

- Risk of deep vein thrombosis due to prolonged immobility – continuation of thromboembolic deterrent stockings, consideration of use of pneumatic compression devices and pharmacological prophylaxis (check timing if planning neuraxial technique).

Cutaneomusculoskeletal:

- Prolonged illness may be associated with weight loss – care with positioning and padding.

Renal:

- Check renal function – may dictate drug choices.

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1.10 September 2017 Spinal cord injury

A 19-year-old patient has suffered a complete transection of the spinal cord at the sixth cervical vertebral level due to a fall, but has no other injuries.

a) Explain the sequence of neurological effects that may develop in the first three months following injury. (6 marks)
b) What disturbances of the cardiovascular (3 marks), respiratory (3 marks) and gastrointestinal (2 marks) systems may occur after three months?
c) List the advantages of choosing a regional anaesthetic technique if this patient is subsequently listed for lower limb surgery. (4 marks)
d) When, and why, may suxamethonium be contraindicated in this patient? (2 marks)

The Chairs acknowledged that this SAQ (reproduced here as it appeared in the exam) had been used before and was answered better on this occasion with a pass rate of 49.3%. "It was considered to be of moderate difficulty. Most marks were lost in part (a), with some candidates being unable to give a coherent explanation of the sequence of neurological events following a spinal cord injury." The SAQ was very similar to those from September 2011 and September 2015, except that the level of the injury is now at the sixth cervical vertebra. Be especially careful to read every word of familiar-looking questions. Cord transection at this level may result in secondary neurological injury to a few segments higher and so at least partial phrenic nerve loss must be considered. Such a patient may require noninvasive ventilation for at least part of the day. Higher cord injuries with complete loss of the phrenic nerve may necessitate long-term ventilation via tracheostomy.

1.11 March 2018 Acromegaly and trans-sphenoidal hypophysectomy

A 54-year-old male with acromegaly presents for a trans-sphenoidal hypophysectomy.

a) What is acromegaly? (2 marks)
b) List the clinical features of acromegaly which are of relevance to the anaesthetist. (8 marks)
c) What other clinical presentations of a pituitary adenoma may be encountered? (2 marks)
d) What specific considerations, including surgical factors, may influence the conduct of anaesthesia in this patient? (8 marks)

This question, reproduced in its original SAQ format, was identical to that from March 2016. The Chairs said that the pass rate was 48.7%: "Again, a previously used question, and as such, disappointingly poorly answered. Candidates did not give enough specific information in the management section, concentrating instead on generic anaesthetic considerations. This probably reflects lack of experience in this area of neurosurgery and lack of appreciation of the challenges of the procedure." More likely, it reflects a failure to learn topics that have previously featured in the Final FRCA.

1.12 September 2018 Guillain-Barré syndrome

A 68-year-old man is referred to the neuro-intensive care unit with suspected Guillain-Barré syndrome (GBS).

a) What is GBS and what are its causes? (3 marks)
b) List the clinical features (6 marks) and investigations/findings (2 marks) that can be used to aid the diagnosis.
c) What are the problems associated with anaesthetising a patient with GBS? (7 marks)
d) What specific treatments are available? (2 marks)

The Chairs' Report of this SAQ (reproduced here in its original format) stated that "Despite a respectable pass rate [56.9%], candidates . . . lacked some knowledge on this subject. The feeling of the examiners was that there was little focus on the answer and [they] feel that time may have been wasted. Very few people knew the correct definition of Guillain-Barré syndrome, nor the correct use of muscle relaxants in these patients." The only change from the SAQ in September 2016 was part (d), which I have answered below.

d) What specific treatments are available? (2 marks)

- Intravenous immunoglobulin.
- Plasma exchange.

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1.13 March 2019 Acute stroke

a) Give an imaging modality recommended by The National Institute for Health and Care Excellence (NICE) for the diagnosis and evaluation of management options of acute stroke. (1 mark)
b) List four specific treatments that can be considered for patients with acute thrombotic ischaemic stroke. (4 marks)
c) What is the potential consequence of severe hypertension in patients with acute ischaemic stroke? (1 mark)
d) Give the levels that systolic and diastolic blood pressure should be below if thrombolysis is being considered for treatment of acute ischaemic stroke. (2 marks)
e) A patient has had a large hemispheric infarction following a stroke. Outline your ongoing management of this patient following admission to critical care. (12 marks)

The Chairs' Report following the SAQ on this topic gave a pass rate of 63.4% and stated that it "was well answered with candidates exhibiting good knowledge. Poorer candidates tended to discuss general ICU management and failed to consider the specific neurocritical care interventions." Don't panic when you read "NICE recommendation" in a question – the guideline is only really needed for three marks which you may know due to your clinical experience anyway. The remainder of the question can be tackled by being organised and applying your knowledge of physiology and neurocritical care.

a) Give an imaging modality recommended by The National Institute for Health and Care Excellence (NICE) for the diagnosis and evaluation of management options of acute stroke. (1 mark)

- Non-enhanced CT brain within 24 hours of symptom onset.
- (CT contrast angiography then recommended if thrombectomy might be indicated and CT perfusion imaging or MR equivalent if thrombectomy may be indicated beyond 6 hours of symptom onset.)

b) List four specific treatments that can be considered for patients with acute thrombotic ischaemic stroke. (4 marks)

- Thrombolysis: alteplase (within 4.5 hours of stroke onset).
- Antiplatelets: aspirin (300 mg within 24 hours and continuing for two weeks, followed by 75 mg daily) or alternative antiplatelet if aspirin intolerant.
- Anticoagulants: heparin initially and then warfarin aiming for INR 2–3 (reserved for patients with stroke due to cerebral venous sinus thrombosis).
- Thrombectomy: in patients with confirmed anterior circulation occlusion (within six hours of symptom onset).
- Carotid endarterectomy: in patients with non-disabling stroke (TIA) and 50–99% carotid artery stenosis on Doppler examination.

c) What is the potential consequence of severe hypertension in patients with acute ischaemic stroke? (1 mark)

- Haemorrhagic transformation (may be fatal due to sudden rise in ICP and risk is increased if thrombolysis has been given).

d) Give the levels that systolic and diastolic blood pressure should be below if thrombolysis is being considered for treatment of acute ischaemic stroke. (2 marks)

- Systolic < 185 mmHg.
- Diastolic < 110 mmHg.

e) A patient has had a large hemispheric infarction following a stroke. Outline your ongoing management of this patient following admission to critical care. (12 marks)

The mortality following a large hemispheric infarction is up to 80% and the priority is to restore perfusion to the ischaemic penumbra through thrombolysis or endovascular thrombectomy. This question does not state whether these reperfusion techniques have been employed. After admission to critical care, it will be important to maintain cerebral perfusion whilst avoiding secondary brain injury and any reperfusion injury. Meticulous supportive care should be provided and the patient closely monitored for malignant middle cerebral artery syndrome (rapidly deteriorating neurological function due to significant cerebral oedema), haemorrhagic conversion and consideration of decompressive craniectomy. Longer-term management will involve discussions with the family regarding potential for major disability or death and involvement of the MDT, including palliative care, where appropriate.

Airway:

- Endotracheal intubation for GCS ≤8, failure to maintain acceptable oxygenation or normocapnia, or bulbar dysfunction.

Respiratory:

- Target PaO_2 greater than 13 kPa.
- Target $PaCO_2$ 4.5–5.0 kPa.

Cardiovascular:

- Invasive BP monitoring, maintain MAP > 85 mmHg and address any hypovolaemia.
- Maintain BP < 185/100 mmHg for the first 24 hours if patient has had thrombolysis or thrombectomy.
- Maintain systolic BP < 220 mmHg in patients ineligible for thrombolysis or thrombectomy to reduce risk of haemorrhagic transformation.
- Facilitate venous drainage: 30-degree head-up tilt, avoidance of tight tube ties, avoidance of excessive PEEP (ideally < 12 mmHg) or mean airway pressures (while ensuring adequate gas exchange, and adopting a lung protective strategy), use of NMBD if coughing or straining on tube.

Neurological:

- Treat seizures.
- Maintain blood glucose 4–11 mmol/l.
- Treat pyrexia (which raises $CMRO_2$).
- Consideration of invasive ICP monitoring targeting < 20 mmHg to help ensure cerebral perfusion pressure > 60 mmHg.
- Sedate adequately to reduce $CMRO_2$.
- Osmotherapy (mannitol or hypertonic saline) if cerebral oedema or risk of impending herniation.
- Consideration of decompressive hemicraniectomy in patients under 60 years old with significant GCS drop, large infarct or evolving cerebral oedema.
- Serial assessments of neurology via sedation holds, guided by ICP monitoring and clinical condition.
- Commencement of aspirin once satisfied that haemorrhagic transformation has not occurred.

General ICU care:

- Gastric protection with PPI.
- Enteral feeding.
- VTE prophylaxis with intermittent pneumatic compression devices (risk of haemorrhagic transformation with LMWH).

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1.14 March 2020 Subarachnoid haemorrhage

A 63-year-old patient is admitted to the Emergency Department with a history suggestive of subarachnoid haemorrhage and a GCS of 10.

a) List three presenting features of subarachnoid haemorrhage. (3 marks)
b) List three congenital conditions that are associated with an increased risk of subarachnoid aneurysm development. (3 marks)
c) List three other risk factors for subarachnoid bleeding. (3 marks)
d) List two imaging modalities that are used in the diagnosis of subarachnoid haemorrhage. (2 marks)
e) Give the upper and lower range of acceptable systolic blood pressure values in a patient presenting with subarachnoid haemorrhage. (2 marks)
f) What grade of severity is this patient's subarachnoid haemorrhage according to the World Federation of Neurosurgeons Scale (WFNS)? (1 mark)
g) List three neurological complications following acute subarachnoid haemorrhage. (3 marks)
h) List three specific complications associated with endovascular coiling following subarachnoid haemorrhage. (3 marks)

The Chairs said that the pass rate for the CRQ on this topic was 74% and that this "is a common question in all parts of the exam. Reassuringly, this was well answered by most candidates."

a) List three presenting features of subarachnoid haemorrhage. (3 marks)

- Sudden onset ("thunderclap"), occipital, severe headache.
- Signs of meningism due to blood in the subarachnoid space – headache, vomiting, neck stiffness, photophobia.
- Reducing consciousness level.
- Development of focal neurology.
- Seizures.
- Cardiac arrest.

b) List three congenital conditions that are associated with an increased risk of subarachnoid aneurysm development. (3 marks)

Aneurysms tend to arise from the vessels of the circle of Willis close to bifurcations.

- Autosomal dominant polycystic kidney disease.
- Ehlers-Danlos type 4.
- Familial intracerebral aneurysm disease.
- Pseudoxanthoma elasticum.
- Marfan's syndrome.
- Hereditary haemorrhagic telangiectasia.
- Arteriovenous malformations.

c) List three other risk factors for subarachnoid bleeding. (3 marks)

- Poorly controlled hypertension.
- Cigarette smoking.
- Cocaine use.
- Excessive alcohol use.
- Trauma.
- Arteriosclerosis.
- Increased size of existing aneurysm.

d) List two imaging modalities that are used in the diagnosis of subarachnoid haemorrhage. (2 marks)

- Non-contrast CT brain *(first-line investigation, highly sensitive for diagnosing subarachnoid blood. Will also diagnose complications e.g. cerebral oedema and hydrocephalus. If a CT brain is negative but subarachnoid haemorrhage is still strongly suspected, a lumbar puncture looking for red blood cells, bilirubin, and xanthochromia is indicated).*
- CT angiogram *(identifies site of aneurysm).*
- Digital subtraction angiography *(may be used if CT angiogram is negative – radio-opaque structures are removed from the image to enhance the view of the blood vessels).*
- MRI brain (*less commonly used due to logistics involved*).

e) Give the upper and lower range of acceptable systolic blood pressure values in a patient presenting with subarachnoid haemorrhage. (2 marks)

Your management of the patient more generally will be according to the principles of management of any brain injured patient aiming to limit the impact of the primary brain injury and minimise the development of secondary brain injury. Autoregulation is lost after acute subarachnoid haemorrhage and cerebral perfusion becomes MAP-dependent. Hypertension should therefore be avoided in patients with unsecured aneurysms to prevent excessive transmural pressure.

- Systolic blood pressure < 160 mmHg.
- Systolic blood pressure > 100 mmHg (or MAP >80 mmHg).

f) What grade of severity is this patient's subarachnoid haemorrhage according to the World Federation of Neurosurgeons Scale (WFNS)? (1 mark)

The WFNS scale is commonly used and provides a means of communicating severity and predicting morbidity, disability, and death after subarachnoid haemorrhage: grade 1 – GCS 15; grade 2 – GCS 13–14 without motor deficit; grade 3 – GCS 13–14 with motor deficit; grade 4 – GCS 7–12; and grade 5 – GCS <7.

- Grade 4.

g) List three neurological complications following acute subarachnoid haemorrhage. (3 marks)

The following could all be suspected in a patient with new neurological deterioration after presenting with subarachnoid haemorrhage.

- Re-bleeding resulting in further brain injury.
- Delayed cerebral ischaemia or vasospasm *(routine nimodipine for 21 days following subarachnoid haemorrhage reduces these risks and systemic hypertension, with euvolaemia, may be used to increase cerebral perfusion in patients with vasospasm and a secured aneurysm).*
- Hydrocephalus.
- Seizures.
- Cerebral oedema.
- Death according to neurological criteria.

h) List three specific complications associated with endovascular coiling following subarachnoid haemorrhage. (3 marks)

Most aneurysms are now managed neuroradiologically instead of with neurosurgical clipping. As well as coiling, where metal coils are deployed within the aneurysmal sac to occlude it, stents can be used to seal the coiled aneurysm off from its parent artery or to divert blood flow from the sac. Stents will necessitate long-term antiplatelet therapy.

- Complications related to vascular access (normally femoral or radial) including haemorrhage, infection, pseudoaneurysm formation.
- Intracranial vessel injury.
- Aneurysmal rupture.
- Cerebral vascular occlusion resulting in ischaemia due to thrombus, embolus (dislodgement from the aneurysmal sac), vasospasm, misplaced catheter or coils.
- Failure to adequately coil the aneurysm.

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1.15 September 2020 Raised intracranial pressure

A 40-year-old patient is admitted to neuro-intensive care following a traumatic brain injury.

a) Define the normal range for intracranial pressure (ICP) in adults and children. (2 marks)
b) Describe the normal appearance of the ICP waveforms. (3 marks)
c) State the equation of cerebral perfusion pressure. (1 mark)
d) List two indications for ICP monitoring following traumatic brain injury. (2 marks)
e) List two invasive monitoring methods of ICP in a patient with traumatic brain injury. (2 marks)
f) At what level is an intracranial pressure monitor zeroed? (1 mark)
g) Give the pressure above which management should be undertaken to lower ICP. (1 mark)
h) List two physiological parameters for which the measurement of jugular venous oxygen saturations ($SjvO_2$) may be used as a surrogate. (2 marks)
i) Describe the correct positioning of a catheter for jugular venous oxygen saturation monitoring and state why malposition will cause error. (2 marks)
j) Give two factors which may cause low $SjvO_2$ and two factors which may cause raised $SjvO_2$. (4 marks)

The original CRQ had the highest overall pass rate for the paper (88.1%). The Chairs said that "The knowledge-based components of this question were answered well. Candidates performed poorly on the components relating to jugular venous oxygen saturation. Most notably on the last section which required the physiological and pathophysiological causes of a low jugular venous oxygen saturation."

a) Define the normal range for intracranial pressure (ICP) in adults and children. (2 marks)

- Adults 10–15 mmHg.
- Older children 5–15 mmHg, infants 3–4 mmHg.

b) Describe the normal appearance of the ICP waveforms. (3 marks)

The normal ICP waveform is triphasic and analysis of the waveform appearance, alongside the ICP value, can help to assess if cerebral compliance is changing.

- P1 "percussion wave" – waveform transmitted by arterial pulsation.
- P2 "tidal wave" – a reflection of P1 so representing intracranial compliance. If brain compliance decreases, P2 will rise and may become higher than or merge with P1.
- P3 "dicrotic wave" – due aortic valve closure (the lowest wave of the three).

c) State the equation of cerebral perfusion pressure. (1 mark)

Sometimes CVP is substituted for ICP if the CVP is greater than ICP. In these circumstances, a negative pressure gradient results such that no venous outflow occurs until ICP exceeds CVP and venous flow starts again.

- CPP = MAP − ICP

d) List two indications for ICP monitoring following traumatic brain injury. (2 marks)

- All patients with traumatic brain injury GCS ≤ 8 and abnormal CT brain scan.
- Patients with severe traumatic brain injury and normal CT brain scan if they have ≥ 2 of the following:
  - Age > 40 years.
  - Motor posturing.
  - SBP < 90 mmHg.

e) List two invasive monitoring methods of ICP in a patient with traumatic brain injury. (2 marks)

- Intraventricular catheter *(also referred to as an external ventricular drain – can be calibrated and can be used to therapeutically drain CSF).*
- Transducer pressure monitoring in subdural, intraparenchymal, subarachnoid, or epidural space. *(Transducer may be a balloon, strain gauge, or fibreoptic tip. Once it is sited, there is no ability to recalibrate it. May not reflect variation of intracranial pressure in different parts of brain.)*

f) At what level is an intracranial pressure monitor zeroed? (1 mark)

- The foramen of Monro, which correlates with the external acoustic meatus in the supine patient with head in neutral position.

g) Give the pressure above which management should be undertaken to lower ICP. (1 mark)

- 22 mmHg.

h) List two physiological parameters for which the measurement of jugular venous oxygen saturations ($SjvO_2$) may be used as a surrogate. (2 marks)

- Cerebral oxygenation.
- Cerebral blood flow.

i) Describe the correct positioning of a catheter for jugular venous oxygen saturation monitoring and state why malposition will cause error. (2 marks)

- A catheter is inserted in a retrograde direction in the internal jugular vein to the jugular bulb, usually on the dominant side (determined by compressing each internal jugular vein and seeing which causes the greatest rise in ICP), and the tip checked at C1/2 intervertebral level on lateral C-spine X-ray.
- Poor positioning will result in admixture from extracranial blood and therefore error.

j) Give two factors which may cause low $SjvO_2$ and two factors which may cause raised $SjvO_2$. (4 marks)

Normal values are between 55 and 75%. Like with measuring mixed venous oxygen saturations when assessing systemic oxygen delivery, it is a question of supply and demand.

Low values:

- Reduction in oxygen delivery: raised ICP, cerebral ischaemia, hypoxia, profound hypocarbia.
- Increased cerebral oxygen demand: seizures, pyrexia.

High values:

- Reduction in cerebral oxygen consumption: coma, hypothermia, cerebral infarction.
- Increased oxygen delivery: hypercapnia, vasodilation.

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1.16 March 2021 Cervical spine surgery

A 45-year-old patient presents for cervical spine surgery. The neurosurgeons have requested prone positioning and neurophysiological monitoring.

a) Describe the arterial supply to the spinal cord. (3 marks)
b) Give three forms of neurophysiological monitoring that may be used during cervical spine surgery. (3 marks)
c) List two ways in which the use of neurophysiological monitoring may require alteration in anaesthetic technique. (2 marks)
d) Give three physiological approaches to minimising the risk of neurological injury during cervical spine surgery. (3 marks)
e) Give three surgical complications of cervical spinal surgery. (3 marks)
f) State six potential complications of general anaesthesia in the prone position. (6 marks)

The original CRQ was well answered, with a pass rate of 80%. The Chairs said that candidates gave "very comprehensive answers. Marks were dropped on the initial sections and less than half the candidates knew the blood supply to the spinal cord. Very few candidates scored full marks on the complications of the prone position."

a) Describe the arterial supply to the spinal cord. (3 marks)

This is core knowledge that is often examined as part of questions on spinal, cardiothoracic, and aortic vascular surgery, during which spinal cord ischaemia may occur as a complication.

- Anterior spinal artery, formed by the union of the two vertebral arteries at the foramen magnum, supplies the anterior 2/3 of the cord (spinothalamic and corticospinal tracts).
- Two posterior spinal arteries are formed from each of the vertebral arteries or the posterior inferior cerebellar arteries, and supply the posterior 1/3 of the cord (dorsal columns).
- Segmental arterial supply. Numerous paired branches perfuse the spinal cord along its length, arising from vertebral, deep cervical, intercostal, aortic and pelvic vessels. The arteria radicularis magna/artery of Adamkiewicz is the biggest segmental artery and forms a major supply to the lumbosacral spinal cord, arising at a variable vertebral level between T8–L4, but typically at T12–L1. It usually originates from an intercostal or, less commonly, a lumbar artery.

b) Give three forms of neurophysiological monitoring that may be used during cervical spine surgery. (3 marks)

Neurophysiological monitoring for spinal cord ischaemia is important in patients undergoing spinal surgery. For this answer you only need to list the different types, but I have included a bit more information as this is also a common viva topic. Spinal cord ischaemia generally causes reduced amplitude and increased latency of measured evoked potentials.

	Description	Other notes
Somatosensory evoked potential	*Peripheral sensory nerves (usually ulnar/ median/posterior tibial) are stimulated and electrodes placed on the scalp to record cortical response.*	*Mainly tests the integrity of dorsal column +/- spinothalamic tracts.*
Motor evoked potential	*Motor cortex is stimulated and electrodes on peripheral muscles record impulses.*	*Mainly tests the integrity of corticospinal tracts. Risks include biting and tongue damage, scalp burns, seizures.*

	Description	Other notes
Electromyography	*Needle electrodes placed into a specific muscle group to detect surgical irritation or damage of a particular nerve.*	*Complete transection of the nerve will result in loss of signal.*
EEG	*Topical scalp electrodes give information about depth of anaesthesia and cerebral blood flow.*	

c) List two ways in which the use of neurophysiological monitoring may require alteration in anaesthetic technique. (2 marks)

- Volatile agents reduce the amplitude of motor evoked potentials – TIVA is therefore more commonly used.
- Neuromuscular block results in loss of MEP and EMG signal and therefore should be avoided.
- Ketamine can increase the amplitude of motor and sensory evoked potentials and may be used to enhance low-amplitude, poorly defined MEP responses.
- Alpha-2 agonists may reduce motor evoked potentials and may therefore be unhelpful during monitored surgery.

d) Give three physiological approaches to minimising the risk of neurological injury during cervical spine surgery. (3 marks)

Physiological prevention of <u>any</u> neurological injury (be it spinal cord, cerebral or peripheral nerve) relates to maintenance of oxygen delivery and perfusion.

- Optimal ventilation to avoid hypoxia and hypercapnia.
- Maintenance of MAP in order to ensure spinal cord perfusion pressure.
- Replacement of any significant blood loss.
- Maintenance of normal acid-base status.
- Maintenance of normothermia.

e) Give three surgical complications of cervical spinal surgery. (3 marks)

Cervical spine surgery can be performed via a posterior approach, as is the case for the patient in this question, but may also be undertaken via an anterior approach. The approach and the level of surgery, would dictate some of the important surgical complications – go back to your anatomy and think what is nearby.

- Spinal cord or nerve root injury due to direct injury, local haematoma, or metalwork migration.
- Bleeding or haematoma resulting in postoperative airway compromise.
- Infection leading to discitis, meningitis, or cerebral abscess.
- Dural tear and CSF leak.
- Damage to local structures – anterior approach surgery may cause damage to the oesophagus, trachea, vertebral and carotid arteries, recurrent laryngeal and hypoglossal nerves, and the sympathetic chain. Posterior approach surgery may cause damage to the vertebral arteries.

f) State six potential complications of general anaesthesia in the prone position. (6 marks)

This is a common viva question too – be systematic in your approach and go by organ system:

Airway:

- Accidental extubation.
- Airway and tongue oedema leading to postoperative airway obstruction.

Respiratory:

- In obese patients, lung expansion may be reduced by failure to accommodate the abdomen within the pre-cut shape of the Montreal mattress.
- (Generally, prone positioning may improve V/Q matching – see intensive care medicine chapter.)

Cardiovascular:

- Abdominal pressure may cause IVC compression reducing venous return and cardiac output.
- Loss of intravenous access on turning the patient.

Neurological:

- Abnormal neck flexion or extension may result in impaired cerebral perfusion and venous drainage.
- Peripheral neuropathies affecting brachial plexus, ulnar nerve at elbow, and common peroneal nerve.
- Central retinal artery occlusion due to pressure on eye, corneal abrasion, ischaemic optic neuropathy.

Gastrointestinal:

- Increased intra-abdominal pressure if care not taken to ensure accommodation of abdomen in cut-out of Montreal mattress resulting in gastric acid reflux with consequent oral and eye irritation.

Cutaneomusculoskeletal:

- Direct pressure effects to face, pinna, breasts, genitalia, femoral triangle.

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1.17 March 2021 Awake craniotomy

a) List two indications for an awake craniotomy. (2 marks)
b) Give two surgical contraindications to awake craniotomy. (2 marks)
c) Give two examples of anaesthetic technique for an awake craniotomy. (2 marks)
d) Give three advantages and one disadvantage of using dexmedetomidine for sedation as part of an awake craniotomy technique. (4 marks)
e) An intraoperative seizure occurs. What immediate management should take place? (2 marks)
f) Give two drugs, with doses, that can be given to terminate seizures intraoperatively. (2 marks)
g) Give two effects of using such drugs on the surgery. (2 marks)
h) What are four specific intraoperative complications that may occur during awake craniotomy? (4 marks)

The Chairs' Report of the original CRQ stated that "Candidates answered this question poorly and this may reflect a lack of experience in neuro-anaesthesia. Knowledge of pharmacology was again poor. Not many candidates knew about the role of dexmedetomidine in this context. Section (f) asked about drugs used to terminate an intraoperative seizure. Very few candidates knew what drugs to give for a seizure, but those who did frequently didn't know the correct doses. It is important to read the question and answer what is asked: the last section of this question asked for specific intraoperative complications, yet most candidates gave general complications." It is a common criticism in Chairs' Reports that candidates give answers that are too general. The pass rate was 40.9%. I would encourage reading the referenced CEACCP article as awake craniotomies are generally rare and many candidates are unlikely to witness one even if they have completed their neuroanaesthesia module.

Scalp blocks come hand in hand with awake craniotomy and are a popular viva question. The sensory innervation of the scalp is as follows:

- *Posterior to the auricle:*
  - *Branches of the cervical plexus (lesser occipital, greater auricular), and the greater occipital nerve.*
- *Anterior scalp:*
  - *Branches of V1 – supraorbital and supratrochlear.*
- *Lateral scalp:*
  - *Zygomaticotemporal nerve (branch of V2).*
  - *Auriculotemporal nerve (branch of V3).*

a) List two indications for an awake craniotomy. (2 marks)

This is generally to perform surgery whilst maintaining real-time neurological assessment of the impact on surrounding brain:

- Tumour excision from an area within or close to functionally important cortex.
- Epilepsy surgery.
- Deep brain stimulation surgery.
- Resection of vascular lesions from vessels supplying functionally important areas of the brain.

b) Give two surgical contraindications to awake craniotomy. (2 marks)

Read the question – it asks for surgical contraindications. The general contraindications are as follows:

Absolute; patient refusal, inability to lay still/flat, inability to co-operate due to confusion, anxiety, low GCS, or learning disability.

Relative; morbid obesity, severe sleep apnoea, anticipated difficult intubation, uncontrollable seizures, chronic cough, young age.

- Highly vascular lesions.
- Significant dural involvement (this will cause pain during resection).
- Low occipital lobe lesions – patients may be unable to tolerate positioning for surgical access.

c) Give two examples of anaesthetic technique for an awake craniotomy. (2 marks)

The term "awake" craniotomy means that the patient is fully awake during cortical mapping and lesion resection but may be sedated or asleep for other parts of the operation. Local anaesthesia with scalp blocks may be used for all methods.

- Local anaesthesia with sedation:
  - Scalp blocks are performed.
  - Conscious sedation is maintained with target-controlled infusions of propofol and/or remifentanil and sedation deepened for the stimulating parts of the operation (Mayfield pins, skin incision, removal of bone flap and dura).
- General anaesthesia ("asleep/awake/asleep")
  - Patient is anaesthetised and an airway (supraglottic or endotracheal tube) is placed. Maintenance may include TIVA.
  - When mapping needs to commence, anaesthesia is reduced and the patient is woken up and the airway removed.
  - Patient can be anaesthetised again and an airway reinserted after mapping is complete.

d) Give three advantages and one disadvantage of using dexmedetomidine for sedation as part of an awake craniotomy technique. (4 marks)

Dexmedetomidine is an alpha-2 agonist (similar to clonidine) which can be used as an infusion for conscious sedation:

Advantages:

- Analgesic properties.
- Minimal respiratory depression.
- Minimal effects on ICP.
- Sedative and anxiolytic properties.
- Minimal effect on interictal epileptiform activities (IEAs) – the presence and location of these IEAs can be used to localise an epileptogenic focus and guide surgical resection.

Disadvantages:

- Bradycardia and hypotension.
- User unfamiliarity.

e) An intraoperative seizure occurs. What immediate management should take place? (2 marks)

Seizures may occur during cortical mapping, the awake phase of the surgery.

- Irrigation of brain tissue with ice-cold saline.
- Declare emergency, ask surgeons to stop, call for help.
- Rapid and succinct A to E assessment, apply 100% oxygen, airway management with SAD (head may be fixed in head pins, distant to ventilator, so insertion of an SAD is usually easier to manage than intubation).

f) Give two drugs, with doses, that can be given to terminate seizures intraoperatively. (2 marks)

If irrigation of the surgical field fails, then proceed to pharmacological management.

- Propofol: 10–30 mg titrated to effect.
- Midazolam: 2–5 mg titrated to effect.
- Thiopentone: 25–50 mg titrated to effect.

g) Give two possible effects of using drugs to terminate seizures on the ongoing surgery. (2 marks)

Electrocorticography (ECoG) refers to placement of EEG electrodes on the cortex to detect interictal epileptiform activity to guide localisation of target in epilepsy surgery.

- May cause significant sedation with need to secure airway, delaying the "awake" phase of surgery and potentially leading to delayed wake up postoperatively.
- Interference with neurophysiological monitoring:
  - Thiopentone activates interictal epileptiform activity (IEA).
  - Benzodiazepines suppress IEA.
  - Propofol has a variable effect on IEA.
  - Most intravenous anaesthetics and benzodiazepines suppress ECoG activity.

h) List four other specific intraoperative complications that may occur during awake craniotomy. (4 marks)

There is a very long list of possible complications, but I have restricted this list to the ones that are more specific to awake craniotomy.

Airway and respiratory:

- Alveolar hypoventilation due to sedation, airway obstruction or apnoea with head immobilised.
- Hypoxia and hypercapnia (leading to poor surgical conditions with brain swelling).
- Failure to resite airway device, laryngospasm.
- Aspiration.

Circulation:

- Difficult to manage hypotension due to sitting position and venous pooling.

Disability:

- Patient intolerance of the procedure due to pain from semi-seated position with immobilised head, catheter irritation, seizures, and need to convert to general anaesthesia.
- Ineffective local anaesthesia leading to technique failure.
- Venous air embolus.
- Focal neurological deficit.

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1.18 September 2021 Posterior fossa surgery

A 55-year-old presents for posterior fossa surgery. The neurosurgeons require the sitting position for surgical access.

a) List three structures contained within the posterior fossa. (3 marks)
b) Describe three neurological features that you would specifically assess for prior to posterior fossa surgery in the sitting position. (3 marks)
c) List two other positions that may be suitable for posterior fossa surgery. (2 marks)
d) List two absolute contraindications to the sitting position for craniotomy. (2 marks)
e) List three complications due to the sitting position for craniotomy. (3 marks)
f) Give two ways in which the risk of development of venous air embolus can be minimised during the sitting position for craniotomy. (2 marks)
g) After calling for help and assessing the patient in a systematic manner, list four steps that can be undertaken to manage a significant venous air embolism in this patient. (4 marks)
h) What is the most sensitive noninvasive monitoring technique for the detection of venous air embolus? (1 mark)

There was no Chairs' Report for this exam sitting as this was the CRQ paper that was withdrawn following difficulties with the online exam platform.

a) List three structures contained within the posterior fossa. (3 marks)

The posterior fossa is posterior to the petrous part of the temporal bone and its inferior boundary is largely formed by the occipital and temporal bones. Its contents are clearly more numerous than this, but these are the main anatomical features.

- Brainstem, which leaves the posterior fossa via the foramen magnum.
- Cerebellum and aqueduct of Sylvius.
- Vertebral and basilar arteries.
- Cranial nerves VI, VII, VIII, IX, X, XI, XII.
- Venous sinuses – sigmoid, transverse, and occipital.

b) Describe three neurological features that you would specifically assess for prior to posterior fossa surgery in the sitting position. (3 marks)

Leading on from (a), it would be important to assess the neurological functions pertinent to the structures in the posterior fossa as they could be already compromised by the disease process or be damaged by surgery.

- Cerebellar function: co-ordination, posture, and gait *(the acronym DANISH was often used in medical school OSCEs, meaning dysdiadochokinesis, ataxia, nystagmus, intention tremor, slurred speech, hypotonia)*.
- Cranial nerve function: in particular bulbar weakness can lead to loss of airway protection and the need for postoperative ventilation.
- Raised ICP: reduced level of consciousness, headache, or vomiting. This may be the result of the pathology or due to the development of hydrocephalus.

c) List two other positions that may be suitable for posterior fossa surgery. (2 marks)

- Supine with head turned, supported by sandbags *(may be suitable for acoustic neuroma or cerebellopontine angle tumours)*.
- Prone *(like the sitting position, this offers good access for midline structures)*.
- Lateral *(good access for lateral structures)*.
- Park bench *(modification of the lateral position with the patient semi-prone, head flexed to face the floor, offering greater access to the midline, avoiding the need for sitting or prone positioning)*.