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CORE SURGERY JOURNAL

Volume 2, Issue 1

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Contents

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Dear Prospective Authors

Thank you for considering the submission of an article to 'Core Surgery'. This is a new journal aiming to educate and inform surgical trainees about relevant 'core' subject topics. Each issue will cover a topic from selected subspecialty fields: General Surgery, Trauma and Orthopaedic Surgery, Plastic and Reconstructive Surgery, Otorhinolaryngology and Neck Surgery, Neurosurgery, Urology, Paediatric Surgery, Cardiothoracic Surgery and Critical Care. Articles will be required to be broad enough to help with preparation for the intercollegiate MRCS examination but also focus on key hints and tips on becoming a higher surgical trainee. Authors are encouraged to submit articles on relevant topics to core surgical training.

Types of Article

Manuscripts are considered under the following sections:

1) Case based discussions
2) Practical procedures
3) Audit
4) Review articles
5) Course reviews
6) Research papers

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Submissions will only be accepted via email and must be accompanied by a covering letter. Please submit your article to **coresurgery@123doc.com.** The covering letter must include a statement that all authors have contributed significantly and accept joint responsibility for the content of the article. In addition any financial or other conflict of interest must be declared.

Manuscript Style

Submissions should follow the style of the Vancouver agreement detailed in the International Committee of Medical Journal Editors' revised 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publication', as found at **http://www.ICMJE.org/**

References

All articles must be referenced appropriately. The Vancouver system of referencing should be used; details can be found at **http://www3.imperial.ac.uk/library/subjectsandsupport/referencemanagement/vancouver/references.** References should be cited using superscript numerals in the order in which they appear. The list of references should reflect this order and names of journals should be abbreviated in the style used in Index Medicus **ftp://nlmpubs.nlm.nih.gov/online/journals/ljiweb.pdf.**

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Format of Articles

Guidelines for the format of respective article types are as follows:

Case Based Discussions

Should be about 1000-1500 words long and should focus on clinical assessment, differential diagnosis or treatment. The basic structure should be as follows:

Abstract: The salient points of the case and discussion.

Case history: Including the initial presentation, clinical setting and problem, investigation and treatment.

Discussion: Covering the critical aspects of the management and the treatment options.

Practical Procedures

Should be about 1000-1500 words long. Although not essential it is highly advantageous if pictures and diagrams are supplied to illustrate the most salient points. Articles should be set out as follows:

- History and pathology
- Indications and contraindications
- Gaining informed consent/explaining procedure to patient
- Equipment required
- Draping/sterile field preparation
- Patient positioning and relevant anaesthetic points
- Documentation of procedure
- Recording of complications and management of such

Audit

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The topic should be relevant to core surgical trainees, and a maximum of 2500 words long. The review should include an abstract and a clinical vignette of a case relevant to the topic. The aim of including a clinical case is to provide a focus for discussion, and to ensure that the review is relevant and useful to our readership.

Course Reviews

Should be a maximum of 1000 words and review a course which is either mandatory or desirable for core trainees and junior higher surgical trainees.

Research Papers

Although the publication of research articles is not a core aim of the journal, Core Surgery welcomes research submissions if thought to be of interest to the readership. Articles should be written using the following headings (title page, abstract, introduction, methods, results, discussion, references). They should be a maximum of 2500 words of text including abstract, 30 references, 3 illustrations or figures. The abstract should be a maximum of 250 words and use the following headings (introduction, methods, results, conclusion). The title page should contain the title of the paper, the full names of the authors, the addresses of the institutions at which the research was carried out and the full postal address, email address and telephone number of the corresponding author.

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Please note that all articles should be submitted with five multiple choice questions (MCQs) or extended matching questions (EMQs) attached, in the style of the Member of the Royal College of Surgeons (MRCS) 'Part A' examination. These questions should have answers and brief teaching notes/discussion included. Examples of the requirements for question style can be found here: **http://www.intercollegiatemrcs.org.uk/old/pdf/samplequestions_MCQ.pdf**

Summary

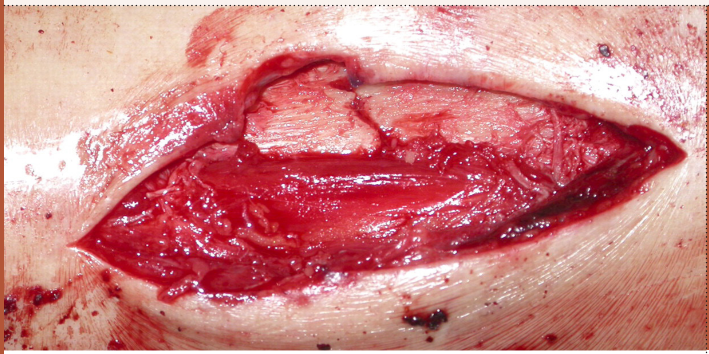
Articles considered for publication will be sent for review by our panel of consultants and surgical trainees. We wish you every success with your submission. Please contact the editorial team with any questions.

Darryl Ramoutar **James Risley** **Conal Quah**
Andrew Titchener **Jeremy Rodrigues** **Vishal Patel**

Co-Founders: 'Core Surgery'

SURGICAL INCISIONS AND WOUND CLOSURE

K Ubayasiri



Surgical incisions and wound closure.
Back to Basics.

This article discusses the general principles involved in deciding when and where to employ a number of surgical incisions and goes on to discuss the principles of wound closure.

Choice and placement of incisions

Surgical incisions may be made for a number of reasons: to allow access to an underlying structure, to excise a superficial structure or to revise a previous scar. A surgical incision must provide adequate access for the operation being performed. Should the initial access to underlying structures be inadequate, the incision must have the capacity to be extended if required. The incision must also have a low complication rate and cause minimal post-operative pain.

Placement of incisions are anatomically based and are ideally made within or parallel to relaxed skin tension lines (Langer's lines). Relaxed skin tension lines (RSTLs) can be defined as the skin-tension lines that are oriented along the furrows formed when skin is relaxed. Relaxed skin tension lines may be revealed by pinching the skin and examining the ridges and furrows revealed. The line of maximum extensibility will be perpendicular to the relaxed skin tension lines and is due to the resting tone and contractile forces of underlying musculature.

Correct orientation of planned incisions is especially important in certain areas, such as the face, to avoid distortion when closing the wound. The closer an incision is to lying within a RSTL, the better the ultimate cosmetic appearance of the scar. Incisions perpendicular to RSTLs are to be avoided if possible, since the greatest amount of lax skin lies in this plane. That is, an incision made parallel to the line of maximum extensibility is unable to utilize the maximum available skin laxity, making wound closure far more difficult.

When traversing a muscle plain, the muscle fibres should ideally be split rather than cut. This muscle preserving approach is especially relevant in the abdomen, where it can help prevent incisional herniae. Nerves and vascular pedicles should not be unnecessarily divided, since this leads to loss of function and a varying degree of ischaemia.

The post operative scar appearance must be acceptable to the patient. Obviously the indication for each respective operation determines this threshold. For example, a large cancer operation will inevitably be more disfiguring that an operation performed for cosmetic reasons, and patient expectations should be managed appropriately.

Midline laparotomy

Midline incisions are the commonest approach to the abdomen and the following structures are divided in order from superficial to deep (a favourite College Viva question):

- **Skin**
- **Subcutaneous fat**
- **Scarpa's fascia**
- **Linea alba**
- **Transversalis fascia**
- **Extraperitoneal/properitoneal fat**
- **Parietal peritoneum**

The incision can be extended inferiorly by cutting around the umbilicus to the left, thus, avoiding the falciform ligament and thereby reducing bleeding.

In the abdomen the rectus muscle has a segmental nerve supply and can, thus, be cut transversely without weakening a denervated segment. Tendinous intersections prevent retraction of the muscle above the level of the umbilicus. Figure 1 shows a number of common abdominal incisions.

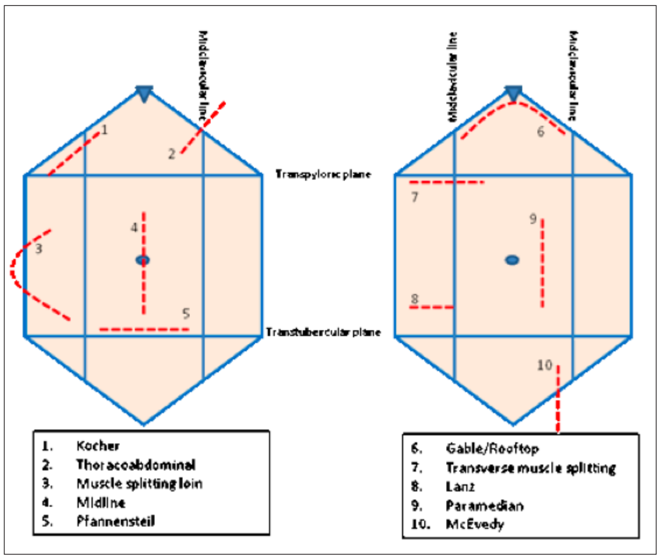


Figure 1: Abdominal incisions

SURGICAL INCISIONS AND WOUND CLOSURE

K Ubayasiri

Wound Closure

Evaluation of wound type and wound depth is critical in planning the best closure method. Wound healing may be achieved by primary, secondary or tertiary intention, each of which are discussed.

The method employed for wound closure is governed by a number of factors. This includes speed of operative wound closure, the lev el of cosmesis required and surgeon preference. Dirty wounds should be irrigated copiously with sterile water or saline prior to closure and devitalized tissue debrided. Adequate haemostasis must be achieved prior to closure in order to prevent haematoma.

There are a number of options available for skin closure (healing by primary intention), namely sutures, adhesives tapes, glues and staples. The advantage of suture use is that they can be used to close almost every type of wound. Primary closure generally provides the most cosmetically acceptable scar.

The suture itself may be naturally occurring or synthetic. The basic characteristics of the suture may then be described as absorbable or non-absorbable, monofilament or braided and dyed or undyed. Synthetic absorbable sutures (eg. vicryl) are degraded via hydrolysis and, thus, stimulate a reduced inflammatory reaction, as opposed to natural absorbable sutures which degrade by proteolysis.

As an example, the midline abdominal incision described above should be closed using non-absorbable monofilament suture to reunite the two sides of the linea alba. 1 cm bites should be taken 1 cm apart. The length of suture required is defined by 'Jenkins Rule'. This states that suture length to wound length should be in the ratio 4:1. Deep tension sutures may be placed according to operator preference. Although fat sutures reduce the amount of dead space, they add no strength to the wound repair. Specific closure of the peritoneum is not essential. For safety, a non-touch technique should be used with sharps meaning needles should only ever be held with instruments.

A meta-analysis comparing sutures versus staples for skin closure in orthopaedic surgery showed a significantly higher risk of developing a wound infection when the wound is closed with staples rather than sutures. However, many of the studies included in the meta-analysis were subject to a number of methodological limitations, including the recruitment of small underpowered cohorts, poorly randomising patients, and not blinding assessors to the allocated methods of wound closure. (1)

Adherence to techniques of tensionless wound closure, wound edge eversion, and atraumatic handling of tissues not only reduces the likelihood of wound dehiscence, but also optimizes scar appearance. Toothed forceps should be used on skin with the teeth used as skin hooks rather than firmly grasping the skin, thereby causing trauma. Layered closure of the wound and undermining may be employed to decrease tension at the skin level. Undermining is accomplished by creating a subcutaneous plane on one or both sides of a wound.

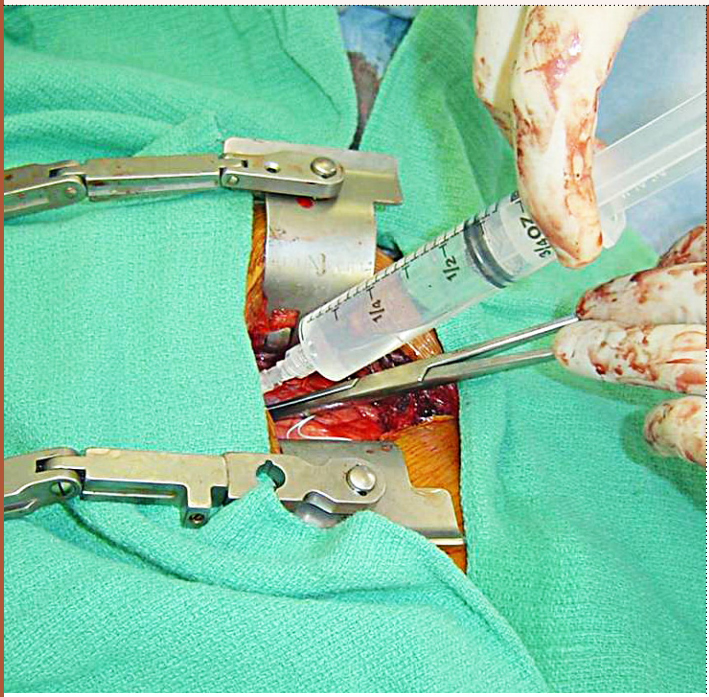
If a wound may not be closed primarily, reconstructive options include healing by secondary intention, local or regional flaps, or skin grafts.

Healing by secondary intention is a treatment option for superficial wounds and occurs when the wound is left open, allowing it to spontaneously contract and epithelialize on its own. Healing by secondary intention takes longer than healing by primary closure and is inappropriate for complex defects where multiple tissue layers are missing and structural support is needed. Frequently, there is increased hypopigmentation of re-epithelialized scars and increased contraction of surrounding soft tissue, which causes drifting of neighboring structures.

Healing by tertiary intention, otherwise known as delayed primary closure, is when the wound is initially cleaned and left open, typically for 4 to 5 days, and then closed with sutures or staples. This method is employed where there is great tissue loss, and the wound must heal by contraction of the wound edges, with the formation of granulation tissue. Resolution of potential problems such as local infection may be first achieved whilst the wound is left open prior to its closure.

SURGICAL INCISIONS AND WOUND CLOSURE

K Ubayasiri



The maintenance of an optimal wound-healing environment, regardless of the type of wound healing employed, involves minimizing infection, debriding devitalized tissues, maintaining vital structural support and tensionless wound closure. This will also help prevent hypertrophic scarring. Drain placement prevents excess fluid collection (eg. haematoma and seroma) and helps avoid infection. Maceration of the surrounding skin may be avoided by the application of appropriate dressings to absorb wound exudates. Dressings also protect the wound from trauma.

Removal of sutures and staples

Non-absorbable sutures and staples require removal, and this is best done at 3-5 days in the head, 7-10 days in the upper limbs, trunk and abdomen and at 10-14 days in the lower limbs.

Tissue adhesives

Tissue adhesives or glues are increasingly used in place of sutures or staples for wound closure. Adhesives carry no risk of sharps injury and are thought to provide a barrier to infection that also promotes healing as well as eliminating the need for suture removal.

In a Cochrane meta-analysis, there was no difference in outcomes between tissue adhesives and the alternatives. However, fewer wounds dehisced when sutures were used. Tissue adhesives were also more time consuming to use than other methods. (2)

Surgical incisions and wound closure.
Back to Basics.

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Questions

1. Order the following structures from superficial to deep in the the order they would be encountered when performing a midline laparotomy.

a. Extraperitoneal/properitoneal fat,
b. Skin
c. Transversalis fascia
d. Parietal peritoneum
e. Scarpa's fascia
f. Linea alba
g. Subcutaneous fat

2. Silk is an example of a natural absorbable suture? True/False

SURGICAL INCISIONS AND WOUND CLOSURE

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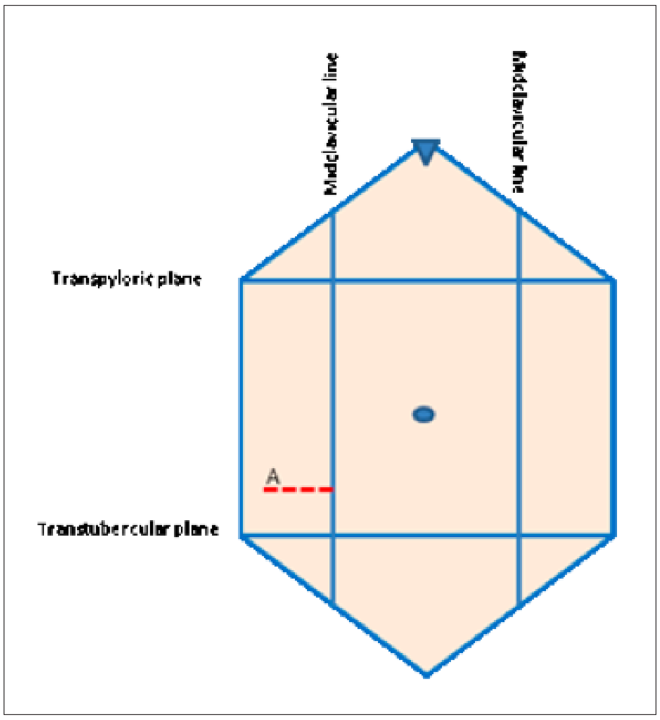
3. What is the name of the incision shown below?

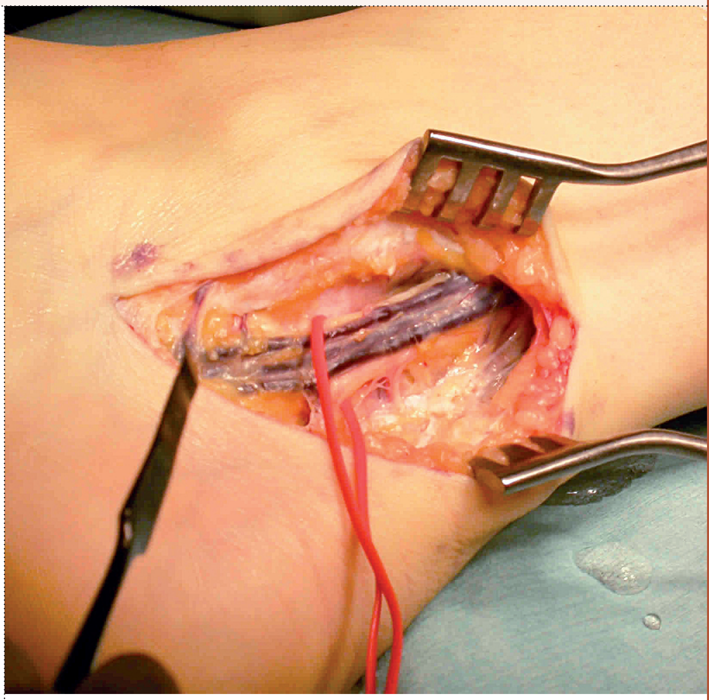


a. Lanz
b. Kocher
c. Gable
d. Rutherford-Morisson
e. McEvedy

4. Incision should ideally be made parallel to the line of maximum extensibility within the skin? True/False

5. After how many days should non-absorbable suture be removed from a wound on the right foot? Please pick the most appropriate answer.

a. 3-5 days
b. 5-7 days
c. 7-10 days
d. 10-14 days
e. They do not need to be removed



Answers

1. b, g, e, f, c, a, d

2. False- it is a natural non-absorbable suture.

3. a (Lanz) - It is a horizontal incision over McBurney's point

4. False- they should be made perpendicular to this, parallel to the relaxed skin tension lines.

5. d Non-absorbable sutures in the lower limb should be removed at 10-14 days.

Removal of sutures:

- 3-5 days in the head,
- 7-10 days in the upper limbs, trunk and abdomen
- 10-14 days in the lower limbs

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DIVERTICULAR DISEASE: STILL A SURGICAL CONDITION?

N Campain and A Bhalla

Diverticular disease: Still a surgical condition?
General Surgery.

Introduction

Diverticula are formed by areas of mucosa herniating through the muscularis propria (outer layers of bowel wall) creating pockets or out-pouchings within a segment of bowel. These herniations occur at areas of weakness within the integrity of the bowel wall, commonly in areas where blood vessels penetrate the muscularis propria. Although diverticula may occur anywhere along the gastrointestinal tract, the vast majority are found within the colon, with over 90% occurring within the descending and sigmoid colon.(1)

The aim of this review is to outline common clinical presentations associated with colonic diverticula and highlight the treatment options available. In order to understand the problems associated with colonic diverticula, we should firstly outline some useful definitions.

Definitions

Diverticulosis – presence of multiple asymptomatic diverticula.
Diverticular disease – multiple symptomatic colonic diverticula

Epidemiology

Approximately three quarters of patients with diverticulosis remain asymptomatic during their lifetime, and it is often an incidental finding during colonic investigation.(2,3) The incidence of diverticulosis increases uniformly with age, affecting 50% of people by the fifth decade and 67% by the eighth decade.(2) Approximately 25% of patients with diverticulosis become symptomatic and develop diverticular disease during their lifetime. Of these, a further third develop further complications and require hospital admission.(4)

With an ageing population, diverticular disease represents an increasingly common disorder encountered by clinicians. Recent studies note that over a 10-year period in the United Kingdom, hospital admission rates for diverticular disease rose to approximately 20.1 – 23.2 per 100,000 for men and 28.6 – 31.9 per 100,000 for women.(5)

Pathogenesis

In essence we do not know exactly why some people develop colonic diverticula. However several theories have been proposed suggesting possible mechanisms. It has been suggested that low fibre diets may prolong gut transit time, thereby producing hard stool (increased water absorption) and so increase intraluminal pressures and thus the probability of mucosal herniation.(6,7) Some studies demonstrate patients with diverticulosis having higher intraluminal pressures, whilst others have observed symptomatic diverticular disease in patients with normal colonic pressures.(2,8)

Complications

Complications of diverticular disease are shown in table 1. Acute diverticulitis and subsequent complications occur as a result of stagnation of bowel contents within diverticula, with the resulting inflammation leading to localised ischaemia and bacterial translocation. Diverticulitis typically presents with signs of systemic inflammation (fever, neutrophilia, tachycardia) combined with pain, nausea and loose stools.(8)

Complication	Features	Investigation/Management
Acute diverticulitis	Left iliac fossa pain, nausea, loose stools, SIRS (Systemic Inflammatory Response Syndrome)	• Fluid resuscitation • Intravenous antibiotics • Often resolves with conservative management
Abcess	SIRS, abdominal pain, palpable mass	• CT • Radiological guided drainage • Surgery
Fistula	Dependent on site of fistula (pneumaturia, recurrent UTI, faeculant PV discharge)	• CT • Planned surgery
Stricture	Abdominal distension, obstruction	• CT • Planned surgery • Stenting
Perforation	Acute abdomen, peritonitis, SIRS	• Radiological drainage • Emergent surgery (Hartmans procedure or primary anastamosis)

Table 1: Complications of Diverticular Disease

Unsurprisingly the commonest site of pain is the left iliac fossa, which directly corresponds to inflammation and irritation of the peritoneal coverings of the sigmoid colon (the commonest site for colonic diverticula).

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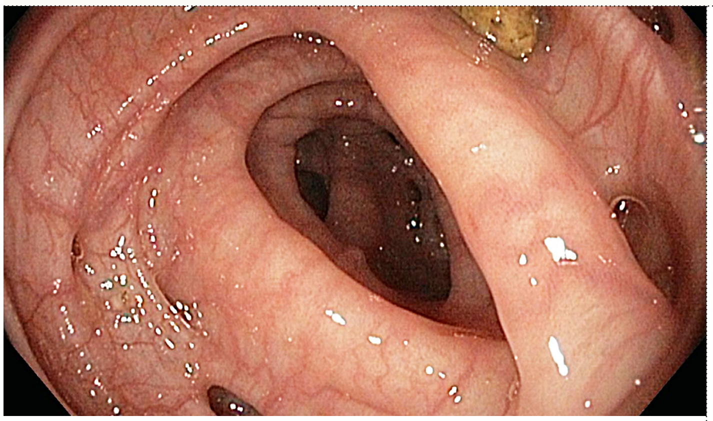


Serious complications of diverticular disease include perforation and peritonitis. Other complications include diverticular fistula and stricture formation. Acute infection with paracolic sepsis may drain by perforation into adjacent structures, such as the posterior vaginal vault in women or the bladder (with colo-vesical fistula the most common type).(1,6) These patients present with recurrent UTIs and pneumaturia or with faeculant vaginal discharge depending upon the exact site of the fistula opening.

Stricture formation may occur after repetitive bouts of inflammation and lead to bloating, colicky abdominal pain and distension.(6) Diverticulitis can cause significant lower gastrointestinal bleeding if vessels within the bowel wall are exposed. However most case settle with adequate resuscitation and conservative management.(1)

Investigation

Diverticula are often diagnosed incidentally when investigating colonic disorders by either endoscopy or double contrast barium enema.(3) In the acute setting, abdominal CT scanning is the modality of choice due to its unique ability to be able to see diverticula, assess inflammation of the bowel wall and look for complications such as perforation, abcess or fistula. Interventional radiological advances also allow CT-guided drainage of organised diverticular abcesses and localised perforations.(3)

Conservative management

The management of diverticular disease remains a controversial area. Recent prospective studies have shown by increasing dietary fibre intake and physical exercise patients may be able to protect themselves from diverticular disease. If colonic diverticula are present the effects of increasing fibre once symptoms have developed is less clear.(3,9)

A high fibre diet, high fluid intake and stool softeners (to reduce intracolonic pressure) remain the basis of outpatient management for uncomplicated diverticular disease.(6) Acute diverticulitis warranting hospital admission should be managed by administering intravenous antibiotics with activity against common gram-negative and anaerobic pathogens. There remains limited data on the optimal duration of antimicrobial therapy and there is minimal evidence to support any particular regimen.(10) Antibiotic treatment of acute uncomplicated diverticulitis has been shown to show resolution of symptoms in 70-100% of patients.(11)

Surgical management

Traditionally, elective resection was recommended if a patient had two or more attacks of diverticulitis. However recent reviews have found no evidence to suggest increased risk of perforation with each successive hospital admission or that the likelihood of a successful response to medical treatment decreases.(11) Over time the management of diverticular disease and subsequent complications has evolved, with increasing use of CT guided drainage and more widespread use of medical management.

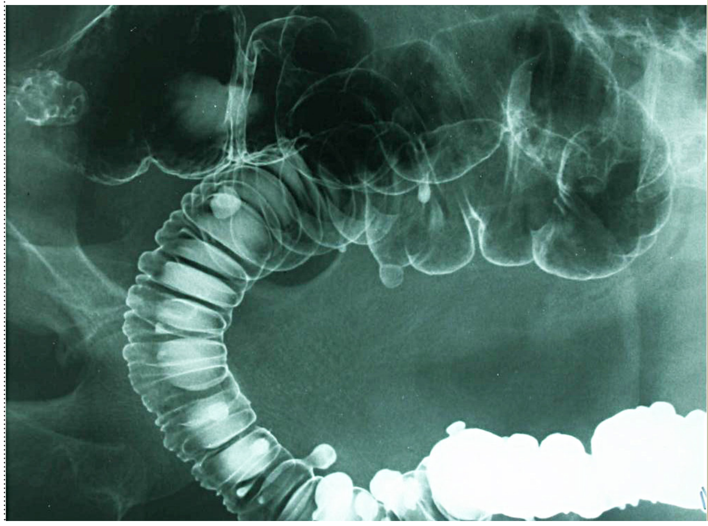
One study of 25,058 patients hospitalised with diverticulitis between 1987-2001, showed minimal changes in frequency of admission each year, but a 2% decrease each year for emergency surgery. Conversely, the incidence of radiological percutaneous drainage has increased by 7% each year.(12) The role of surgery is limited to several complications of diverticular disease and is summarised in table 2.

Indications for surgery in diverticular disease are:[2, 3]
· Acute inflammation failing to respond to medical management
· Undrainable paracolic sepsis/uncontrolled sepsis
· Free perforation leading to purulent or faecal peritonitis
· Planned surgical resection for stricture (or intracolonic stenting)
· Obstruction secondary to diverticular mass or stricture
· Elective resection for diverticular fistula (to prevent recurrent infections)
· Inability to exclude carcinoma

Table 2: Indications for Surgery

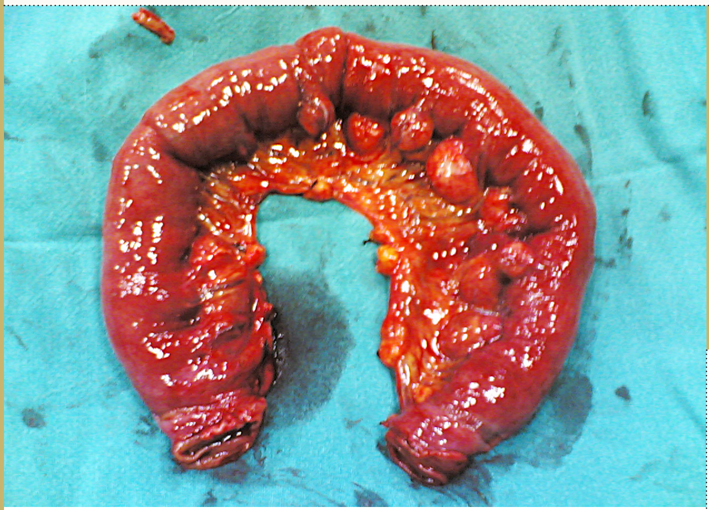
Summary

Diverticular disease is a common condition in an ageing population. Traditionally care of these patients frequently required operations, however improved antibiotic treatments and recent advances in radiological techniques have allowed more patients to be managed conservatively. Surgical trainees have to aware of diverticular disease and modern treatments for complications that may arise. The role of planned surgery in asymptomatic patients continues to be a controversial area.



DIVERTICULAR DISEASE: STILL A SURGICAL CONDITION?

N Campain and A Bhalla



Questions

1. Which of the following is a classification system for diverticular perforation?

a. Le Fort
b. Hinchey
c. Breslow
d. Child-Pugh

2. Management options for perforated diverticular disease do NOT include?

a. Hartmans procedure with colostomy formation
b. Percutaneous drainage
c. Primary anastamosis with sigmoid resection
d. Sigmoidoscopy

3. Which of the following is NOT a branch of the IMA (inferior mesenteric artery)?

a. Left colic artery
b. Superior rectal artery
c. Middle colic artery
d. Sigmoid artery

4. Which of the following is NOT typically associated as risk factor for the development of diverticular disease?

a. Increasing age
b. Diabetes
c. A low fibre diet
d. Connective tissues disorders

5. Which of the following investigations is NOT indicated in the context of acute diverticulitis?

a. Enema with water-soluble contrast
b. Sigmoidoscopy
c. CT scan
d. Abdominal x-ray

Diverticular disease: Still a surgical condition?
General Surgery.

Answers

1. B:

The Hinchey classification system can be used to help decide whether a diverticular abscess may be amenable to percutaneous drainage (stage 1 or 2). Abscesses less then 5cm diameter may resolve with antibiotic treatment alone.

Hinchey classification of peritoneal contamination in diverticulitis

Stage 1: Pericolic or mesenteric abscess
Stage 2: Walled-off or pelvic abscess
Stage 3: Generalised purulent peritonitis
Stage 4: Generalised faecal peritonitis

2. D - Endoscopy is contraindicated in perforated diverticular disease.

In the past faecal or purulent peritonitis was managed with a three-stage procedure, with formation of a transverse colostomy and control of sepsis being the aim of the initial operation. Later the affected segment of colon would be excised at a second operation, with restoration of bowel continuity and reversal of the colostomy carried out in a final third operation.(13) The operative mortality of this approach was reported as nearly 25%.(14)

The two-stage Hartman's type procedure was subsequently found to reduce operative mortality, with some patients only undergoing the first operation and learning to live with a stoma to avoid the associated risk of a second laparotomy for colostomy reversal. Recent studies have reported favourable outcomes in certain patients of using a one-stage primary anastamosis technique. A multi-centre randomised controlled trial of 105 patients found that primary resection resulted in significantly less post-operative peritonitis, fewer reoperations and a shorter hospital stay when compared with secondary resection.(15) However, patient factors (haemodynamic instability, presence of anaemia, nutritional status, immunosuppression), disease factors (degree and nature of peritoneal contamination) and technical factors must all be assessed by the operating surgeon to determine if the patient is a candidate for primary anastamosis.(16)

3. C - Middle colic artery.

This is a branch of the SMA (superior mesenteric artery) and thus contributes to the blood supply of the mid-gut. Diverticular disease is most common in the sigmoid colon which takes its blood supply from the IMA.

DIVERTICULAR DISEASE: STILL A SURGICAL CONDITION?

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4. B - Diabetes.
A low-fibre diet, increasing age, connective tissue disorders, constipation and medications which increase intracolonic pressure (such as opioids, NSAIDS and corticosteroids) have all been associated with the epidemiology of diverticular disease.

5. B - Sigmoidoscopy.
Endoscopy is not recommended during acute diverticulitis due to the increased risk of worsening bowel inflammation and a higher risk of perforation. A barium enema should also be avoided during severe acute diverticulitis due to the risk of perforation and leakage of barium contrast into the peritoneum. CT scanning is the imaging modality of choice.

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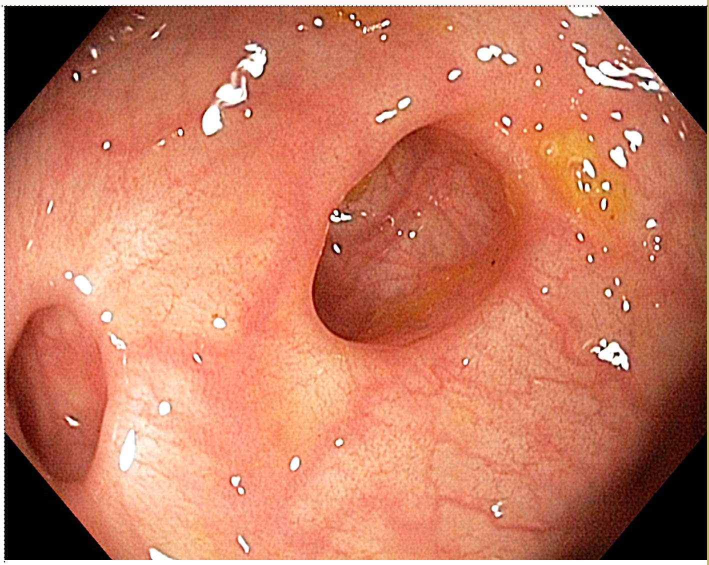

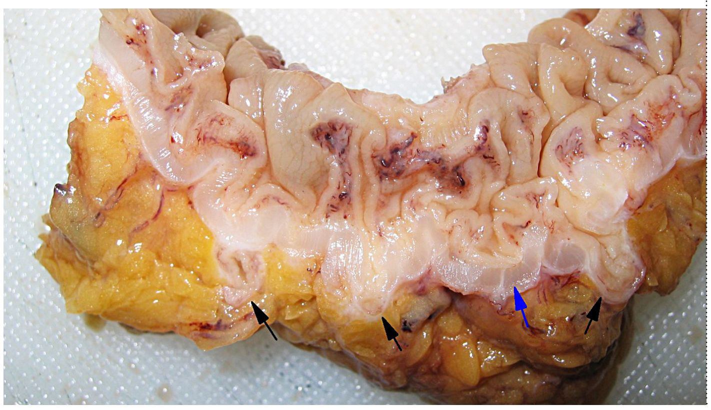

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SUPRACONDYLAR FRACTURES OF THE ELBOW IN CHILDREN

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Trauma & Orthopaedic Surgery.

Abstract

Supracondylar fracture is a common injury in children aged 1-7 years old and accounts for 60% of all elbow fractures in children and 17% of orthopaedic paediatric hospital admissions. These injuries present a challenge to orthopaedic surgeons due to their high risk of associated complications.

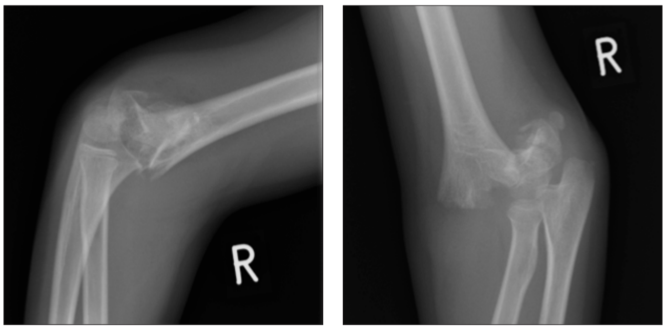
These injuries are classified into extension (90-98%) and flexion (2-10%) types according to the mechanism of injury and displacement of the distal fragment. Extension types are further classified according to the Gartland Classification. Type I fractures are treated conservatively and have a low complication rate. However Type II and Type III injuries commonly require an escalating level of operative management, from closed reduction plus or minus percutaneous Kirschner wire insertion to open reduction, according to the clinical presentation.

Careful attention must be paid to the patient on initial examination as this will determine the urgency of treatment required. A thorough neurovascular examination is required as up to 19% have associated neurovascular injury. Other musculoskeletal injuries must be excluded. A pulseless pale upper limb following a supracondylar fracture is a surgical emergency and requires urgent open reduction, exploration of the fracture site and potentially vascular surgical input. Following appropriate treatment, most patients have an excellent long-term outcome.

Case Report

A 12 year old boy presented to Stepping Hill Hospital, Stockport in July 2011 after falling forwards off his bicycle and onto an outstretched right hand. He suffered immediate pain and deformity of his right arm and subsequently attended A&E for treatment.

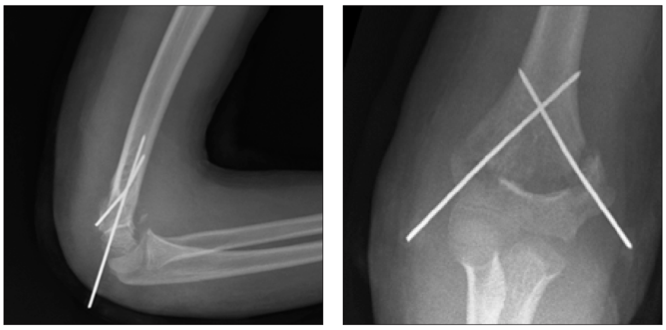
He was found to have a swollen, bruised medial aspect of the elbow on examination. His right hand was pink and warm with a patent radial pulse. He had no tenderness in his hand, wrist or shoulder. Sensation and motor function throughout the right upper limb was intact. Initial x-rays were taken (Figures 1-2) and a backslab was applied.



Figures 1-2: AP and lateral radiographs demonstrating Type IIIa Supracondylar

Fracture

After referral and assessment by the orthopaedic SHO on-call he was admitted to the paediatric unit for elevation of the arm and overnight neurovascular observations. The following morning he required an open reduction of the fracture and stabilisation using two percutaneous Kirschner wires, one medially and one laterally. A wool and crepe dressing was used to protect the elbow. He was discharged and seen after one week where x-rays were repeated (Figures 3-4). The wires were removed four weeks post-operatively and he was allowed to mobilise the elbow as tolerated.



Figures 3-4: Open reduction of the fracture and stabilisation using two percutaneous Kirschner wires

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Introduction

A supracondylar fracture is defined as a fracture just proximal to the medial and lateral epicondyles of the distal humerus. This is a common injury among children but they often present a challenge to orthopaedic practitioners. Gartland observed “the trepidation with which men, otherwise versed in the management of trauma, approach a fresh supracondylar fracture” (1) due to being difficult to treat and significant complication rate.

Supracondylar fractures usually result from a fall on an outstretched hand.(2) Such injuries account for up to 60% of all elbow fractures in children and are responsible for 17.9% of paediatric orthopaedic admissions,(3, 4) the second most common reason for paediatric orthopaedic admission. Supracondylar fractures are most common in the 0-3 years (26.7%) and 4-7 years (31.6%) age groups,(4) with fractures of the distal radius being most common between 8-16 years. Injuries among males are more common (64%) than in females and less than 2% are open fractures.(5)

Supracondylar fractures are initially classified as Extension-type injuries which occur in 90-98% of patients and Flexion-type which are seen in the remaining 2-10% of patients.(5, 6)

Extension-type injuries occur when the patient falls onto an extended outstretched arm, with force travelling through the olecranon and forcing the distal humerus metaphysis into extension. Flexion-type injuries often result from a direct blow onto the posterior aspect of a flexed elbow,(7) leading to an anterior displacement of the distal fragment (Figures 5-6).

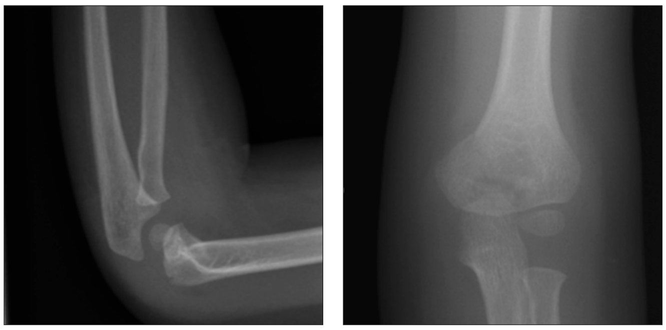


Figure 5-6: 3-year old girl with a Flexion-type Supracondylar fracture

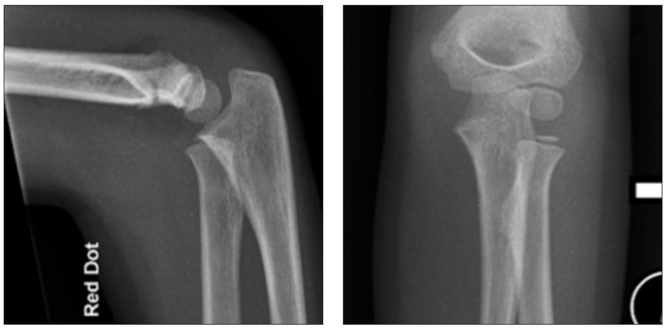
Classification of Supracondylar Fractures

Extension-type injuries were originally classified by the Gartland Classification,(1) a radiological based classification system which divides these injuries into type I (non-displaced), type II (minimally to moderately displaced), and type III (severely displaced). Wilkins modified the classification as to the level of cortical contact present between the fragments and presence of rotational deformity(8) (Table 1).

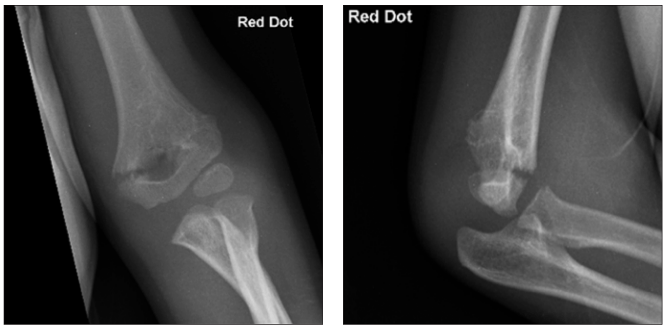
Type of Injury	Gartland	Wilkins Modification
I	Non-displaced	Non-displaced
II	Displaced, intact posterior cortex	IIa: Displaced, intact posterior cortex
II		IIb: As above + rotational deformity
III	Severely displaced, no contact between fragments	IIIa: No contact between fragments, posteromedial displacement of distal fragment
III		IIIb: No contact between fragments, postero-lateral displacement of distal fragment

Table 1: The Gartland Classification and Wilkins Modification (1, 8)

The Gartland classification is a useful guide to the severity of the fracture but although intra-observer reliability is high in type III extension injuries and all flexion-type injuries it can be poor in low-grade fractures.(9) The lateral view x-ray is important to distinguish the type of fracture. In type I injuries (Figures 7-8) the anterior humeral line, if drawn to the level of the elbow, will bisect the capitellum. In type II fractures (Figures 9-10), which are essentially “greenstick” injuries as the posterior cortex remains intact, the capitellum is posteriorly displaced and is not bisected by this line. Type III fractures (Figures 1-2) are fully displaced hence there is no cortical contact on x-ray.



Figures 7-8: 6 year old girl with a Type I Supracondylar Fracture



Figures 9-10: 6 year old girl with a Type I Supracondylar Fracture

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Although there is no specific classification for flexion-type supracondylar fractures, they can be classified as type I, II and III according to the displacement of the distal fragment.

Relevant Anatomy

The supracondylar region of the humerus is a weak point in the bone, bordered by the olecranon and coronoid fossae. The fracture line which results is typically a transverse fracture passing through the olecranon fossa, with or without displacement. Musculature and important neurovascular structures are related to this area and can suffer injury following fracture.
The radial nerve spirals around the posterior aspect of the midshaft of the humerus and then runs anterior to the lateral epicondyle, between the brachioradialis and brachialis. It divides into the superficial and deep branches. The deep branch splits the supinator and supplies all the extensor muscles of the forearm except the "mobile wad" of brachioradialis and extensor carpi radialis brevis and longus. The superficial branch passes between the brachioradialis and extensor carpi radialis longus to supply the radial aspect of the dorsum of the hand 10.

The median nerve lies medial to the brachial artery at the level of the elbow, superficial to the brachialis muscle. This nerve splits the two heads of pronator teres and runs between the flexor digitorum superficialis and profundus muscles towards the hand. The anterior interosseous nerve arises from the median nerve just distal to the pronator teres and supplies the deep muscles of the flexor compartment of the forearm.

The ulna nerve passes posterior to the medial epicondyle of the humerus and enters the forearm between the two heads of the flexor carpi ulnaris. This nerve supplies the flexor and extensor carpi ulnaris as well as the small muscles of the hand.

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The brachial artery is a continuation of the axillary artery within the upper arm and travels along the antero-medial aspect of the arm, superficial to brachialis. It enters the cubital fossa from antero-medial direction, beneath the bicepital aponeurosis, and divides into the radial and ulnar arteries at the level of the radial head.(10) It has a rich anastemosis around the elbow joint.

Associated Injuries According to Fracture Type

Approximately 16% of extension-type III fractures show evidence of neurological injury. The median nerve is most commonly affected (58.9%) followed by radial (26.4%) and ulnar nerves (14.7%).(11) Neuropraxia is the most common nerve injury observed(12) following which motor function usually resolves within three months and sensory function within 6 months. An incomplete palsy (i.e. motor loss but no sensory loss) has a better prognosis than a complete palsy.

The median nerve and its anterior interosseous branch are at greatest risk of injury in postero-lateral (type IIIb) injuries, with up to 50% of patients with this injury exhibiting median nerve symptoms. The radial nerve can be injured by an anterior spike of the proximal fragment of the humerus in type IIIa (posteromedial) fractures. The ulnar nerve is not commonly injured in extension type injuries.(7)

Acute vascular injury results from high energy trauma, for example a fall from over four foot in height or a road traffic accident, and has been reported in approximately 3.2-14% of supracondylar fractures but only present in children with extension type III fractures.(5, 13-16) In type IIIb fractures the brachial artery may be tethered by the proximal fragment following postero-lateral displacement of the distal fragment. However, as the brachial artery provides a rich anastemotic circulation to the elbow, ischaemia of the arm following complete brachial artery occlusion is rare.(7) Median nerve injury often accompanies brachial artery impingement.

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Flexion injuries can be troublesome. 31% of flexion-type injuries required open reduction compared to 10% of all extension-type injuries over a 10-year period in one series.(17) There is no overall increased risk of neurovascular injury but the ulnar nerve is injured in approximately 19% of flexion injuries compared to in 3% of extension injuries.(7, 17)

History and Examination

Children with a supracondylar fracture present with an acutely painful, swollen elbow following a fall onto the affected limb and associated with loss of function.(7) A rapid assessment is required to identify the type of fracture, degree of displacement, any neurovascular symptoms, and evidence of compartment syndrome.

Establish the exact mechanism of injury while obtaining a history. Ask when and how the injury occurred and if there were any witnesses. Ask the child if they have any numbness, paraesthesia, or if they are unable to move their fingers.

Before proceeding to examination, provide the patient with suitable analgesia so that examination of the affected limb is possible. Examination follows the orthopaedic principle of "look, feel, move".
Look at the arm for swelling, bruising, deformity, the colour of the limb, and presence of soft tissue compromise or open wounds. If few clinical signs are evident, assess for tenderness of the distal humerus. Displaced fractures may have an "S-shaped" deformity, or dimpling in the antecubital fossa which is associated with marked swelling of the elbow. Bruising over the antero-medial aspect of the forearm may be a sign of brachial artery injury.(7)

Feel for temperature of the limb, swelling, and tenderness. Always feel for the brachial and radial pulses and compare them to the unaffected side. Compare central and peripheral capillary refill time. If there are signs of limb ischaemia consider using a Doppler probe or pulse oximetry to assess vascular integrity.

Move the fingers, hand, wrist and shoulder if possible to establish neurovascular integrity as well as assess for other injuries; distal radius fractures, for example, are associated with 5% of supracondylar fractures and if present increase the risk of the patient developing compartment syndrome.(7) Assess the patient's level of pain on passive flexion or extension of the fingers to rule out an impending compartment syndrome.

Neurovascular status must always be examined for and carefully documented as injuries to such structures around the elbow joint are common (Table 2).(7, 10, 18) It is important to repeat neurovascular examination on regular intervals and especially after any form of intervention to monitor for any changes in neurovascular status of the limb.

Nerve	How to Test
Median	Motor: Finger flexion Sensory: Index finger
Anterior Interosseous	Motor: "OK" sign
Radial (Superficial Branch)	Sensory: Dorsum of hand, web space between thumb and index finger
Radial (Deep Branch)	Motor: Wrist dorsiflexion and finger extension
Ulnar	Motor: Finger abduction and adduction, wrist adduction Sensory: Little finger

Table 2: Neurological Examination of Peripheral Nerves of the Forearm and Hand

Investigations

Provide adequate analgesia prior to sending the patient for X-ray. Obtain anatomical lateral and antero-posterior views on x-ray to accurately diagnose the type of fracture present. X-rays can be difficult to interpret in the paediatric patient as the majority of the joint is cartilaginous in the younger child but the correct ossification centres can be easily remembered by the

CRITOL mnemonic:
Capitellum: 2 weeks
Radial Head: 4 years
Internal (Medial) Epicondyle: 6 years
Trochlea: 8 years
Olecranon: 10 years
Lateral Epicondyle: 12 years

Management

Patients require analgesia and stabilisation of the fracture in the emergency department, commonly in the form of a backslab. Always repeat x-rays and neurovascular examination after backslab application to assess for any displacement of the fracture. The subsequent management of the patient depends on the type of fracture.

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Type I fractures are treated non-operatively. Treatment using a collar and cuff, to allow early mobilisation and prevent the development of elbow stiffness, is usually sufficient. If this is not tolerated an above-elbow backslab and broad arm sling can be used as a short-term treatment, with the elbow held at 90° and in a neutral position with respect to pronation and supination.(19) Type II injuries require orthopaedic assessment to decide on definitive treatment. Type IIa injuries can be treated with either fully conservative means or by a manipulation under anaesthetic.(7, 20) Kirschner wires are occasionally required to maintain position. Type IIb injuries however require reduction of the rotational element of the injury and therefore will require a closed or open reduction plus stabilisation with percutaneous Kirschner wires.(20)

Type IIIa and IIIb injuries will require open or closed reduction plus fixation of the fracture using percutaneous Kirschner wires.(21) Open reduction is often necessary for these injuries.(20) In the absence of neurovascular or significant soft tissue compromise, emergency surgery is not required. Sibinski et al (2006) found that patients with uncomplicated type III injuries showed no difference in the length of operation and hospital stay, incidence of open reduction and patient outcome if operated on within 12 hours of injury or later.(22) It is therefore recommended that patients undergo operative intervention during daytime trauma lists unless they develop a significant complication.

The optimal treatment with Kirschner wires is a controversial topic. The use of one medial and one lateral wire, or "cross wires", is biomechanically the most stable and is advocated in the literature(20, 23) but medial wire insertion is linked to a 7.7% risk of iatrogenic ulnar nerve injury, rising to 15% if the elbow is hyperflexed during wire insertion.(12, 24) The risk of ulnar nerve injury is reduced by inserting the wire using a mini-open technique. Skaggs et al (2001) found that fixation with two divergent lateral wires plus immobilisation in a backslab showed no difference in outcome to using cross wires for Gartland type II and III fractures.(24)

Patients with a white, pulseless, cold arm in the presence of a supracondylar fracture require emergency surgical exploration of the fracture site in order to ensure that the brachial artery is not trapped between fragments prior to reduction and stabilisation of the fracture.(25) Vascular surgical input with such injuries is advisable as vascular reconstruction may be required. Should a patient develop neurovascular compromise after initial treatment with closed reduction plus or minus Kirschner wire insertion, the fracture site requires urgent surgical exploration. Timely exploration is associated with an excellent outcome.(25)

Treatment of the pink, pulseless limb however is more controversial. Current advice follows that given by Griffin et al (2008), who assessed several previous studies and concluded that a child with a pink, pulseless limb can be managed expectantly following successful fracture reduction. If further symptoms of increased pain, ischaemia or vascular compromise develop they will require full surgical exploration of the fracture site and brachial artery.(26, 27)

Complications

Immediate complications of injury include pain, deformity, and neurovascular injury. An important early complication is compartment syndrome, which is more likely following high energy trauma. Symptoms include increasing forearm pain and increased pain on passive extension of the fingers. Later symptoms include paraesthesia, pallor of the limb, and reduced perfusion and pulse. If a compartment syndrome is suspected, the patient requires fasciotomy as an emergency procedure.

Complications resulting from management of supracondylar fractures include stiffness, infection, and neurovascular injury. Although recovery of range of motion is usually rapid in children, stiffness of the elbow joint is associated with prolonged immobilisation, increasing severity of injury, and an age of over 5 years.(28) Kirschner wire insertion is associated with injuring the ulnar nerve during percutaneous fixation of the distal humerus and infection.(5, 11, 22)

Late complications of injury include progressive cubitus varus deformity following malunion of a supracondylar fracture, which can rarely lead to a "tardy palsy" of the ulnar nerve years after the original fracture.(5, 29) Heterotopic ossification (myositis ossificans) following contusion of the triceps or brachialis muscles, and Volkmann's ischaemic contracture following a missed compartment syndrome, are rare complications.(16)

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Prognosis

Patients with type I or IIa injuries have an excellent prognosis following conservative treatment for their fracture. Type IIb and III injuries have a poor result if managed suboptimally. In one series, type IIb and III injuries were linked to a reoperation rate of up to 29% for further displacement and development of cubitus varus in 12% (20) prior to the development of a treatment protocol. Once all type IIb and III injuries were treated by an experienced surgeon and a management protocol was established, the reoperation rate was reduced to 0%.

Summary

Supracondylar fractures are common paediatric orthopaedic injuries which present in a varying degree of complexity, according to their level of displacement and associated injuries. All patients presenting with a supracondylar fracture require a thorough assessment as these injuries cannot be underestimated. However, if treated appropriately and in a timely fashion, patients will have an excellent outlook.

Questions

1) A 5-year old boy has fallen off a slide and presents with right elbow pain. On looking at the x-ray you find that the distal humerus is angulated posteriorly and rotated but not fully displaced. How would you classify this fracture according to Wilkin's Modification?

a. Type I
b. Type IIa
c. Type IIb
d. Type IIIa
e. Type IIIb

2) At what age does the ossification centre of the Trochlea become visable?

a. 2 years
b. 4 years
c. 6 years
d. 8 years
e. 10 years

3) Which structure passes posteriorly to the medial epicondyle of the humerus?

a. Median Nerve
b. Ulnar Nerve
c. Radial Nerve
d. Musculocutaneous Nerve
e. Brachial Artery

4) You wish to test the Anterior Interosseous nerve of the forearm on examination. Which test tells you that innervation of this nerve is intact?

a. Spreading fingers apart
b. Holding a piece of paper between the middle and ring fingers
c. Extension of the index finger
d. Flexion of the fingers
e. Making an "OK" sign

5) You are examining a 4 year old child with a diagnosed supracondylar fracture and you find that their injured arm is pale and you cannot find a radial pulse. What is your next step in this child's management?

a. Provide analgesia, a backslab and elevate the arm
b. Inform seniors immediately and keep the child NBM
c. Manipulate the fracture in A+E under sedation
d. Assess the neurological status of the limb
e. Admit the patient for the following morning's trauma list

Answers

1) Answer: Type IIb. Wilkin's Modification of the Gartland Classification is as follows:

Type I:	Non-displaced
Type IIa:	Displaced, intact posterior cortex
Type IIb:	As above + rotational deformity
Type IIIa:	"Off-ended" fracture, posteromedial displacement of distal fragment
Type IIIb:	"Off-ended" fracture, posterolateral displacement of distal fragment

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2) Answer: 8 Years. Visability of the ossification centres of the elbow can be remembered using the CRITOL mnemonic:

Capitellum:	2 weeks
Radial Head:	4 years
Internal (Medial) Epicondyle:	6 years
Trochlea:	8 years
Olecranon:	10 years
Lateral Epicondyle:	12 years

3) Ulnar Nerve

At the level of the elbow, the Median nerve and Brachial artery pass anteriorly to the brachialis muscle to enter into the cubital fossa. The Radial nerve spirals around the posterior aspect of the humerus and then runs anterior to the lateral epicondyle, between the brachioradialis and brachialis. The Musculocutaneous nerve travels anterolaterally across the elbow to become the lateral cutaneous nerve of the forearm. The Ulnar nerve passes posteriorly to the medial epicondyle. Knowledge of this is essential as the Ulnar nerve can be injured during insertion of Kirschner wires from a medial direction.

4) Making an "OK" sign

The Ulnar nerve innervates the interosseous muscles of the hand. Remember "PAD DAB"; the three palmar interossei adduct the fingers (holding a piece of paper between fingers) and the four dorsal interossei abduct the fingers (spreading the fingers apart). Extension of the index finger is performed by the extensor indicis and extensor communis muscles, innervated by the Radial nerve. Flexion of the fingers is performed by the flexor digitorum superficialis, innervated by the Median nerve. The Anterior Interosseous nerve innervates flexor pollicis longus (FPL), the radial half of flexor digitorum profundus (FDP), and pronator quadratus. An "OK" sign is made by the action of FPL and FDP.

5) Inform seniors immediately and keep the child NBM

A pale pulseless limb is a surgical emergency. You MUST inform seniors immediately, keep the child NBM, inform the anaesthetist and ensure theatre is available. The child needs open reduction and exploration of the fracture site as soon as possible to prevent complications such as compartment syndrome and irreversible limb ischaemia. Analgesia and splintage can be given for comfort while theatre is being prepared for the patient. Do not manipulate in A&E as you may cause further damage to neurovascular structures.

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SPLIT THICKNESS SKIN GRAFTING: A STEP-BY-STEP GUIDE

M Singh, O Tillo

Split Thickness Skin Grafting: a step-by-step guide.
Plastic & Reconstructive Surgery.

What is it?

A split-thickness skin graft (STSG) is a shaving of skin, involving the entire epidermis and a variable thickness of dermis, but not down to subcutaneous fat, taken from one area of the body and transferred to an area with no skin coverage.

The area a STSG is taken from is called the donor site and the area to be grafted the recipient site:

The donor site – ideally, this should be an area with similar skin pigmentation to the area to be grafted. It should also be an area with a relatively flat surface, if possible, to aid graft harvesting e.g. the lateral aspect of the thigh.

The graft will leave a defect extending from the epidermis to the dermis. This area heals by epithelialization, spreading from the remnants of dermal appendages (e.g. hair follicles, sweat glands etc.). The area simply requires dressing to allow epithelialization to occur.

The recipient site – this is the area with full thickness skin loss requiring grafting.

The recipient site, must have a vascular bed in order for a skin graft to take.

Underlying conditions that compromise wound healing such as venous stasis, and arterial insufficiency should be optimised prior to grafting. An optimal healthy wound bed can also be prepared by use of negative pressure vacuum assisted dressings.

Graft healing, or take is promoted by the following characteristics:

a) Absence of gross infection
- Ideally the wound should be clean and free from infection. The presence of particular organisms such as Beta-Haemolytic Streptococcus(1) is a contra-indication as it can cause graft necrosis. However, grafts can also be lost due to excessive growth of other organisms such as Pseudomonas Aeruginosa.(2)

b) Absence of fluid between the graft and the recipient tissue
- This requires meticulous haemostasis of the wound bed and often meshing of the skin graft to allow fluid to escape from under the graft.

c) Absence of excessive movement
- Excessive movement of a skin graft and the resultant shear can prevent a skin graft taking. Often, if a graft is to be placed over/near a joint, the joint must be immobilised for a period of up to a week.

The process of STSG healing involves three main steps:

a) Plasmic imbibition
- During the first 48 hours, the STSG has no established circulation. It must therefore rely on diffusion to obtain nutrients and dispose of waste products.

b) Inosculation
- After 48 hours, anastomoses begin to form between fine recipient site capillaries and those present on the skin graft.

c) Capillary ingrowth
- New blood vessels from the recipient site grow into the graft and form the definitive circulation.

Graft takes after about 5 to 7 days and consolidates over the following week.

When to use one?

a) Indications:

- STSGs usually allow faster healing of a wound than secondary intention
- When a tissue defect is too large to allow healing by secondary intention
- When secondary healing can lead to adverse effects such as wound contracture, especially over joints
- In suboptimal wound conditions where secondary suturing might lead to wound dehiscence
- For wounds with delayed healing
- Following debridement of necrotic tissue or a wound, such as a burn
- Following excision of skin cancers, or resurfacing muscle flaps

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b) Contra-indications:

- Beta-haemolytic Streptococcus
- Grossly contaminated wound
- Non-graftable bed: for a skin graft to take, the recipient site must be able to provide a blood supply to the graft. Therefore the graft will not take over large areas with a poor supply, such as bare bone stripped of periosteum or tendon stripped of paratenon

The risks to be explained to the patient include:

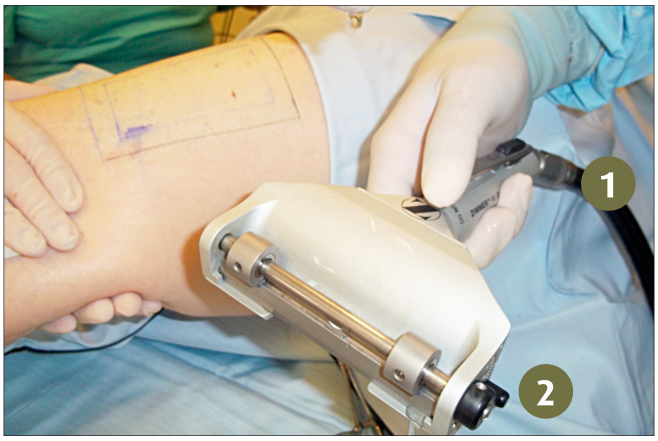
- Infection – both to the donor site and the graft
- Bleeding – rarely a big problem, but could occur at the recipient site
- Donor site wound problems – pain, itching and hypo/hyperpigmentation
- Scarring – (fishnet appearance if meshed), skin discoloration, uneven skin surface
- Graft loss – rarely loss of the complete graft, usually only partial
- Delayed wound healing – if partial graft loss occurs
- Poor cosmesis – a STSG will never look like the normal surrounding skin, abnormal pigmentation, thin appearance, lack of hair growth
- Contractures – a late complication of STSGs can be contracture, can be problematic around joints

3) Operative technique

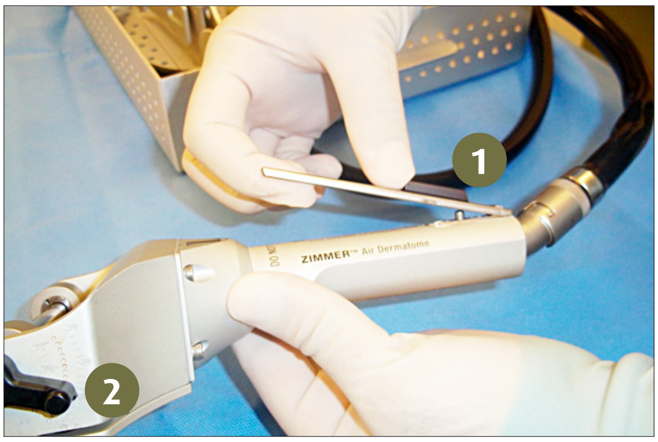
Special equipment required:

a) Harvesting device

The most commonly used method of graft harvesting is by use of an electric or air driven dermatome. Other methods include a Watson's or Humby knife, manually harvesting a graft. Although the plastic surgeon may not use it often these days, it is usually available in every hospital and is an invaluable tool when skin grafts need to applied in emergency procedures.



1. Connector to attach to air or power outlet
2. Switch to adjust depth of graft

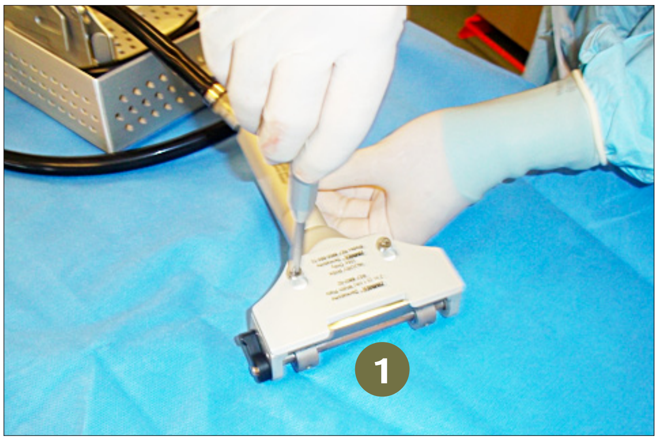


1. Handle with safety switch
2. Switch to adjust depth of graft
Figures 1 and 2: Dermatome

The above is an example of a modern dermatome. The on switch is located on the handle and should be in the safety position until just before the graft is taken and then again afterwards.

On the side, near the blade, is a switch to adjust the depth of the skin graft to be taken. It is measured in 1,000ths of an inch. STSGs are commonly between 8 and 12 1,000ths of an inch, the lower the number the thinner the graft. The thickness varies with the age of the patient (children and the elderly both have thinner skin and so require thinner grafts to be split thickness) and the anatomical site (with thicker skin on the back for example).

The next variable to check is the width of the exposed blade. The width of the blade is constant, it is the width plate that is mounted on to the blade that is variable. The size can range from 1 inch to 4 inches, although it is rare to use 1", but all other size are used reasonably frequently. Typically, it is either 3 or 4 inches wide, depending on the size of the graft required.



1. Area of exposed blade
Figure 3: Blade and blade plate being fitted to dermatome

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b) Mesher

A mesher is often used to allow a skin graft to cover a larger area and also reduce the risk of failure due to fluid under a graft. It basically results in small perforations being made in the graft to allow it to stretch further. When a skin graft is harvested, it will contract due to the unopposed action of elastic fibres within the graft. This results in an overall shrinking of the size of the graft compared with the donor site.

A STSG can be used to cover a larger area by meshing the graft. The degree of meshing is measured by a ratio e.g. 2:1, or 3:1, which estimates how much larger area the graft will cover once stretched e.g. a 2:1 mesh will result in theoretically twice as much area being covered by the graft. Small grafts can be meshed with a scalpel blade, although this mainly helps prevent fluid accumulation beneath the graft, rather than increase the area covered.

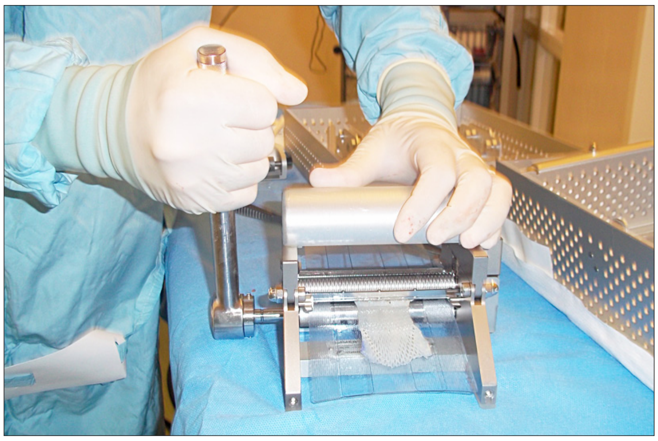

Figure 4: Mesher in use

There are essentially two main types of meshers, one in which the dermacarrier, on which the graft is placed before passing through the mesher, comes in different meshing ratios. As it passes beneath the roller in the mesher, the blades cause perforations where the ridges on the dermacarrier make contact, resulting in perforations. The ratio of the mesh is determined by the width between ridges on the dermacarrier. The other mesher employs a flat dermacarrier, with no ridges, and rollers with blades spaced differentially to influence the ratio in which the graft is meshed. It is vital to be familiar with the one supplied in your theatre.

Stages of grafting:

1) Preparation

- Pre-operatively, ideally, the patient should stop any anticoagulants, if possible
- Most recent swabs of the wound checked to exclude infections that may cause graft failure
- STSGs can be harvested under local or general anaesthetic
- All equipment checked
- Patient adequately prepped, draped and anaesthetized

2) Wound debrided down to healthy, bleeding tissue and haemostasis performed

- It is important to try to remove excessive granulation tissue in the wound bed

3) Size of graft needed marked on a suitable donor area

- A common site is the outer lateral thigh, as it is a broad, flat area of skin.(3)

4) Donor site and dermatome blade lubricated

- Use either copious amounts of normal saline or paraffin oil

5) Have an assistant stretch the donor area to ease harvesting

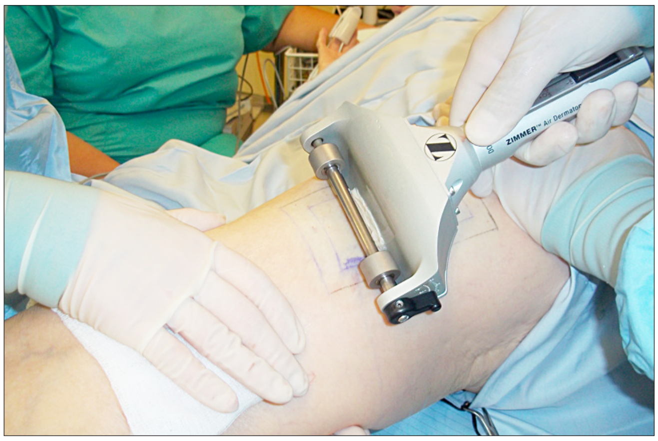

Figure 5: graft being harvested. Note tension maintained by the surgeon's free hand and appropriate assistance

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6) Harvest STSG using dermatome

- Apply gentle pressure with the dermatome blade flat and held at about a 45 degree angle to the skin
- Easiest to harvest moving dermatome away from your body
- Check depth by looking at wound created. Superficial grafts leave many small bleeding points, deeper grafts leave fewer bleeding wider points, but tend to bleed more. If subcutaneous fat is visible, then the graft has become full thickness. This may either be due to excessive pressure or an incorrect depth setting on the dermatome. In this scenario, stop harvesting and lay the skin back in to the wound, securing it with sutures, as needed, and harvest from a new area
- After harvesting adequate amount of skin, tilt the blade away from the body and lift off the skin surface to cut the harvested skin.

7) Apply e.g. Kaltostat to the donor site and usually apply long-acting local anaesthetic topically e.g. Chirocaine

- Then dress with gauze, wool and crepe and leave in-situ for two weeks, unless complications occur

8) Remove graft from dermatome

- Carefully remove graft from dermatome with two pairs of toothed forceps

9) Place graft on dermacarrier with shiny side (underside) facing upwards

10) Mesh graft to appropriate ratio

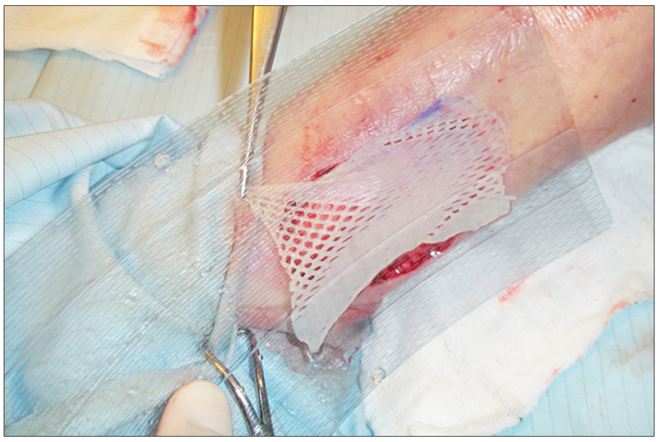

Figure 6: Meshed skin graft (still on original carrier from mesher) being applied to wound. As the graft is meshed 'dermis up', the graft can easily be transferred straight onto the wound without having to turn the graft over

11) Lay graft on wound and carefully remove from meshing tray

- Graft should be laid with shiny side (deeper surface of skin graft) in contact with wound bed

12) Once graft is in position, with shiny side facing wound, trim and secure in place

- Trim excess of skin graft lying over normal skin
- Grafts can be secured in many ways e.g. sutures, staples, or skin glue on the edges of the graft
- If the graft is covering a large area, it can be secured in the central portion with quilting sutures/glue

13) Dress graft with non-adhesive dressing (Jelonet/Mepitel). Over the dressed graft, a bolster dressing (sponge or gauze) should be applied and secured, either with sutures, or skin staples. Bolsters act to apply gentle pressure and help secure the graft and prevent collection of fluid under the graft. In difficult areas, a VAC dressing can be applied over the graft to secure and splint it. The area is then covered with gauze, wool and crepe.

14) If the graft is over a joint or mobile area, such as muscle, the joint should be immobilized, which may require external splintage until the graft has taken.

15) Bring the patient back for a graft check in 5-7 days and a donor site wound check in two weeks

- For the first few weeks after a skin graft the area should be gently moisturized and the patient advised to avoid direct sun exposure for at least 6 months.

SPLIT THICKNESS SKIN GRAFTING: A STEP-BY-STEP GUIDE

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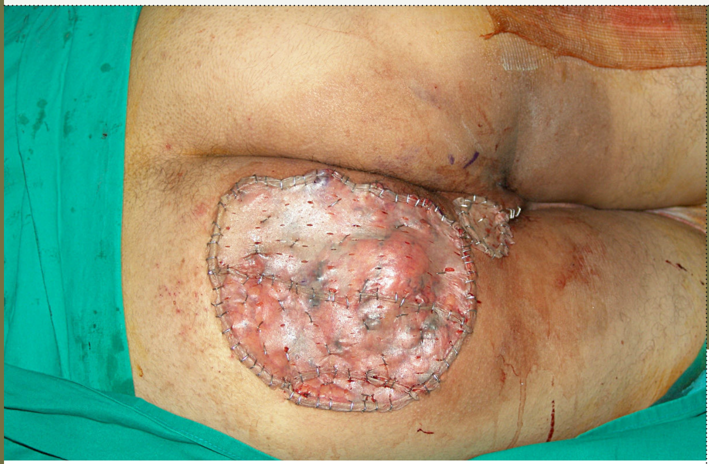

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Questions

Please select the single best answer from the following questions:

1) A split-thickness skin graft should involve the following layers:
a. the epidermis only
b. the epidermis and dermis only
c. the epidermis, dermis and subcutaneous fat
d. should be harvested down to underlying fascia
e. should include a variable thickness of underlying muscle

2) The following increases the likelihood of a skin graft taking:
a. wound microbial colonization
b. fluid between the graft and the wound bed
c. movement at the wound site
d. debridement of the recipient site
e. presence of necrotic tissue at the recipient site

3) Skin graft take occurs by the following steps:
a. Plasmic imbibition -> Inosculation -> Capillary ingrowth
b. Inosculation -> Capillary ingrowth -> Plasmic imbibition
c. Capillary ingrowth -> Plasmic imbibition -> Inosculation
d. Plasmic imbibition -> Capillary ingrowth -> Inosculation
e. Inosculation -> Plasmic imbibition -> Capillary ingrowth

4) The following are contra-indications for the use of split-thickness skin grafts:
a. wounds with delayed healing
b. following excision of skin cancers, or resurfacing muscle flaps
c. following debridement of necrotic tissue or a wound, such as a burn
d. wounds with avascular recipient beds
e. when a tissue defect is too large to allow healing by secondary intention

5) The following are not recognized risks of split-thickness skin grafts:
a. donor site hypo/hyperpigmentation
b. an uneven skin surface
c. a thickened appearance
d. a lack of hair growth
e. contractures around joints

Answers

1. b.
2. d.
3. a.
4. d.
5. c.

Authors

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CARDIAC IMAGING FOR THE SURGICAL TRAINEE

MA Rodrigues and A Sengupta

Cardiac imaging for the surgical trainee.
Cardiothoracic & Critical Care.

Abstract

Cardiac disease is a common and important co-morbidity of patients undergoing surgery. Firstly, it can be the indication for the surgery, such as cardiac valve pathology or coronary artery disease (CAD). Secondly, and perhaps more importantly, potential cardiac complications can affect fitness to undergo anaesthesia or an operation and may also be a consequence of surgery.

Cardiac imaging assists diagnosis and risk stratification of patients. As with many areas of imaging, cardiac imaging is a specialist field that is rapidly advancing. Surgical trainees are often among the first doctors to assess patients prior to surgery, and are closely involved with their postoperative care. Therefore whilst surgeons do not require an extensive knowledge of cardiac imaging, an appreciation of the modalities available is helpful.

In this article we discuss the common cardiac imaging modalities and review their roles in non-cardiac and cardiac surgery, concentrating on two important disease processes; ischaemic heart disease (IHD) in non-cardiac surgery and valve disease in cardiac surgery.

Cardiac imaging modalities

Chest X-ray (CXR)

The CXR is one of the most commonly ordered radiology investigations. It uses x-rays to produce a 2-dimensional image of the thorax and surrounding soft tissues. The standard CXR is a postero-anterior (PA) CXR taken at full inspiration. Unwell or frail patients may be unable to stand for the PA CXR and an antero-posterior (AP) view can be used. The main limitation of an AP CXR is magnification of the mediastinum, making the assessment of cardiomegaly unreliable.

CXRs are quick, non-invasive and easy to perform. They use a relatively small amount of radiation, meaning serial examinations can be performed and compared to assess a patient's progress. Whilst they predominantly provide information about the lung fields, an assessment of left ventricular function (LVF) can be made.

Echocardiography

Echocardiography uses ultrasound to provide a quick, non-invasive assessment of the heart. It can be used to assess a variety of aspects, including ventricular systolic function, valves, and congenital and structural abnormalities. Transthoracic echocardiography (TTE), the most common type of echocardiography, uses an ultrasound probe placed over the thorax to produce 2D images of the heart.

Often TTE is sufficient to assess cardiac structure and function. However, the views can be limited by increased body habitus, which increases the thickness of soft tissues between the probe and the heart, and emphysema, which can result in air trapping in the lungs, impeding the ultrasound waves. Furthermore detailed assessment of the mitral valve is difficult with TTE due to the depth of tissue between the probe and the valve.

Transoesophageal echocardiography (TOE) is an invasive investigation in which a probe containing an ultrasound transducer in its tip is positioned in the distal oesophagus. This allows the ultrasound probe to be much closer to the heart compared with TTE, resulting in clearer images of the valves, cardiac outflow tract and atria. TOE requires the patient to be fasted and additional medical staff to assist, takes longer to perform and carries the risk of oesophageal perforation.

3D echocardiography uses multiple transducers on the ultrasound probe and appropriate software to produce 3D images in real time. Image reconstruction allows detailed anatomical assessment, particularly of the aortic and mitral valves.

One of the drawbacks of 3D TTE is its limited resolution. 3D TOE improves image resolution due to its proximity to the target tissue.

Cardiac Stress Tests

Stress echocardiography compares wall motion in response to a physical or pharmacological stress with a baseline assessment when the patient is "at rest", helping to assess inducible ischaemia and cardiac function. The stressing agent is usually a positive inotrope, such as dobutamine, given intravenously.

CARDIAC IMAGING FOR THE SURGICAL TRAINEE

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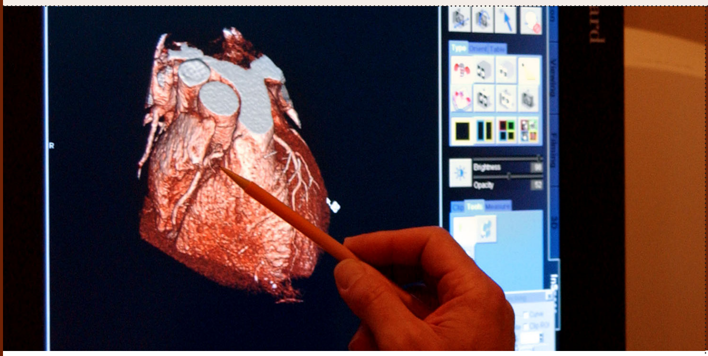

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A nuclear stress test is another form of cardiac stress testing in which a radiotracer, usually technetium-99 or thallium-201, is given intravenously. The radiotracer is extracted from the circulation by the myocardium in proportion to its blood supply. Images are taken before and after a "stress" using a gamma camera. This allows the identification of areas of myocardium supplied by diseased coronary arteries, as well as the severity of ischaemia.

Stress testing does not directly image the coronary arteries and is therefore unable to assess atherosclerotic plaques. Complications of stress testing include chest pain, palpitations and myocardial infarction (MI). Contraindications include multi-vessel coronary artery disease (CAD), recent MI, unstable angina and severe aortic stenosis.

X-ray Angiography

X-ray angiography is an invasive procedure, which involves cannulating the coronary arteries via a peripheral (radial or femoral) artery, injecting contrast and using x-rays from various orientations to assess luminal diameter. It allows the measurement of luminal stenosis and the identification of atherosclerotic plaques, as well as allowing treatment with stents. A left ventricular angiogram can also be performed, providing some information on systolic function.

Angiography does not image the vessel wall, provide information about plaque composition or evaluate cardiac function. Additionally, consideration must be given to the contrast load in patients with renal dysfunction and those taking metformin.

Computed Tomography

Computed tomography (CT) uses x-ray sources and detectors mounted on a rotating gantry and computer software to generate axial "slices" which can be reformatted into any plane.

For CT to accurately image the heart and produce motion-free images, each axial "slice" must be acquired faster than a heartbeat. Increasing the speed of gantry rotation and using multiple detectors has made electrocardiogram (ECG)-gated image acquisition possible. With ECG-gating the CT data acquisition is coordinated with the patient's ECG, allowing images from the same phase over multiple cardiac cycles to be acquired.

Cardiac CT can be used to assess coronary calcification. In this setting a non-contrast scan detects calcified plaques within the coronary arteries, allowing an estimation of CAD. Most other uses of cardiac CT, such as assessing coronary arteries and valves, involve IV contrast +/- a saline flush. For CT angiography (CTA) the contrast and saline are administered at specific times to allow the left side of the heart (and the coronary arteries) to be opacified whilst the right heart is filled with the saline.

Cardiac CT is fast, non-invasive, provides excellent spatial resolution for assessment of anatomy, and allows semi-quantitative assessment of function.

One of the drawbacks of cardiac CT is the relatively high radiation dose. Recently steps have been taken to reduce the radiation dose by using ECG-gating.(1) Early evidence suggests the radiation dose can be reduced by up to 80%(2) whilst maintaining similar diagnostic accuracy to standard CTA protocols and x-ray angiography.(3) The test requires a significant diastolic period, which can be achieved or prolonged with the use of beta-blocker therapy. Patients with an irregular heart rate, such as atrial fibrillation, are not suitable for ECG-gated cardiac CT.

Magnetic Resonance Imaging (MRI)

MRI uses a strong magnetic field and radio-frequency pulses to rotate nuclei within atoms of the body. Nuclei from different tissues rotate at different speeds. This can be detected and computer software is used to produce an image. Cardiac MRI uses ECG-gating and rapid image acquisition sequences to allow assessment of the anatomy and function of the heart.

MRI is non-invasive and does not use ionising radiation, which makes it an attractive imaging modality. The main drawbacks are the lack of availability of cardiac MRI and the relative contraindication of certain medical implants, such as some pacemakers, defibrillators and cochlear implants, although modern medical implants are increasingly MRI compatible. Gadolinium-based contrast has been associated with nephrogenic systemic fibrosis, a rare systemic disorder, in patients with acute or chronic renal failure and perioperative liver transplant patients.(4) In such patients gadolinium–based contrast should therefore be avoided if possible.

CARDIAC IMAGING FOR THE SURGICAL TRAINEE

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Cardiac imaging for non-cardiac surgery

Anaesthesia and surgical procedures place an increased strain on the cardiovascular system. Consequently major cardiac complications are an important association of non-cardiac surgery, occurring in 2% of unselected patients,(5) and up to 34% in high-risk patients,(6) with resultant increases in length of stay, morbidity and mortality.(7,8)

As the age of the population increases, the typical surgical candidate is likely to have more co-morbidities. Therefore, even with advances in medical care, the prevalence of perioperative cardiac complications is likely to continue to be significant.

Cardiac imaging, in combination with clinical assessment, plays an important role in preoperative risk assessment. It helps identify patients who may benefit from preoperative interventions, aggressive perioperative haemodynamic management and closer postoperative monitoring.

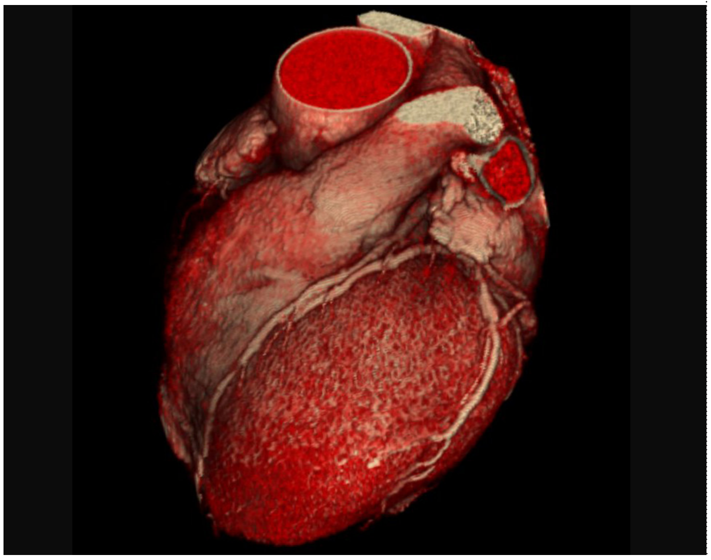
In this section we will look the various imaging modalities for assessing IHD.

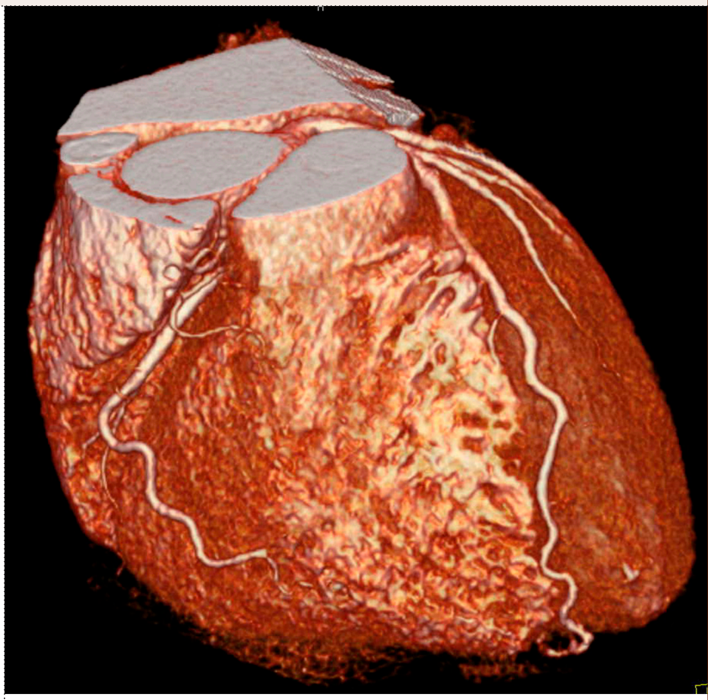
CXR

The CXR is a commonly requested preoperative investigation. For surgical patients, the indication for a CXR is often to assess for lung pathology or in the emergency setting, to identify a pneumoperitoneum. The CXR can play a role in assessing LVF, which is often secondary to IHD.

Signs of LVF on a PA CXR include cardiac enlargement, with a cardiothoracic ratio of greater than 50%, upper lobe venous diversion, pulmonary oedema and pleural effusions (typically bilateral). The extent of these radiological changes, in addition to clinical assessment, helps establish the severity of LVF. Serial CXRs are useful to assess response to treatment.

There is little evidence for routine preoperative CXRs when a reliable clinical assessment has been performed and no specific indication for CXR has been identified. Indeed some series have shown that only 0.1% of routine preoperative CXRs showed an abnormality that would alter management.(9)





Echocardiography

We will focus on the use of echocardiography in the assessment of IHD and LVF in this section. The assessment of valves will be discussed in the cardiac surgery section.

In the context of IHD, TTE can provide information on the extent of MI, by identifying cardiac wall motion abnormalities, LVF, by measuring left ventricular ejection fraction, and the consequences of MI, such as papillary muscle rupture, ventricular septal defect and left ventricular aneurysm.

The role of resting TTE prior to elective major non-cardiac surgery is contentious. It is the most commonly ordered specialised cardiac investigation before major non-cardiac surgery, partly because it is non-invasive, readily available and does not expose the patient to ionising radiation or radioactive isotopes.(10)

Whilst some groups have shown that systolic dysfunction predicts poorer postoperative outcomes,(11,12) within these studies echocardiographically determined left ventricular ejection fractions were actually poor markers of cardiac risk. Furthermore recent studies(13,14) have shown that preoperative echocardiography does not provide information that improves patient survival in elective surgery. Indeed preoperative echocardiography significantly increased postoperative mortality and length of stay, possibly due to side effects of unnecessary medications prescribed on the basis of echocardiography. Further research is therefore needed to clarify the usefulness of routine echocardiography in this setting.

CARDIAC IMAGING FOR THE SURGICAL TRAINEE

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Stress Echocardiography

In contrast to resting echocardiography, which only detects wall motion abnormalities from established infarcts, stress echocardiography is able to identify inducible ischaemia, which may occur during the operative period. This helps guide perioperative drug therapies, such as beta-blockers and statins, and identifies patients most likely to benefit from increased peri and postoperative monitoring. Furthermore it helps determine which patients may benefit from coronary revascularisation prior to their surgery, and those patients who should avoid surgery.

In a recent large population cohort study, non-invasive cardiac stress testing (which included stress echocardiography) prior to major elective non-cardiac surgery resulted in significantly improved survival whilst reducing length of stay in patients with a high pre-test risk of perioperative cardiac complications.(15) Importantly the benefits for patients at intermediate cardiac risk were small and probably do not justify the routine use of stress echocardiography in this cohort. In contrast, those at low risk who underwent cardiac stress testing actually had increased mortality rates.

Current American College of Cardiology and American Heart Association guidelines emphasise stress testing specifically in individuals who are undergoing intermediate to high-risk surgery and have one or more clinical risk factors (for example, ischaemic heart disease, congestive heart failure, cerebrovascular disease, diabetes, or renal insufficiency).(16)

Whilst both stress echocardiography and nuclear stress tests are used in preoperative assessment, recent evidence suggests stress echocardiography has better diagnostic accuracy.(17,18)

X-ray Angiography

This is the currently the gold standard for diagnosing CAD. Identifying vulnerable atherosclerotic plaques within coronary arteries preoperatively allows identification of those patients at higher risk of a cardiac event in the peri and postoperative period. Whilst some information regarding plaque vulnerability can be gained using x-ray angiography, it does not image the vessel wall or assess the composition of the plaques.

Coronary CT Angiography (CTA)

Coronary CTA allows visualisation of the coronary arteries, detection of coronary stenosis and has excellent diagnostic accuracy for coronary atherosclerotic plaques.(19,20) Studies have shown the predictive value of plaque characteristics and size detected on coronary CTA but further work is needed to improve reproducibility and accuracy.(21,23)

CTA has a high negative predictive value, up to 100%.(24) Therefore in patients with a low to intermediate risk of CAD, a negative CTA can effectively exclude CAD without the need for x-ray angiography. In such patients, it may be possible to start with the calculation of a calcium score using a non-contrast CT scan, which correlates with the degree of coronary artery calcification. A low calcium score has a high negative predictive value for CAD, whilst reducing the radiation dose compared with CTA. Additionally it does not require intravenous contrast or beta blockade. This strategy forms the basis of initial investigation for low risk patients with stable angina according to recent NICE guidelines.(25)

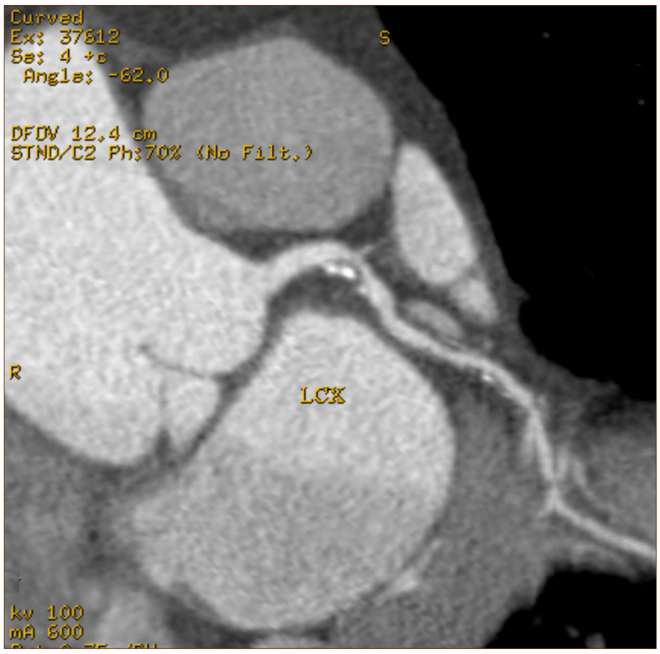

Figure 1: CTA showing a 50-75% stensosed circumflex comprising atheroma and calcification.

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MA Rodrigues and A Sengupta

MRI

Assessment of the coronary arteries with MRI is difficult due to their small size and tortuous course, combined with respiratory motion and cardiac contraction movement artefacts. MRI is therefore not routinely used to directly assess coronary arteries.

Myocardial perfusion imaging identifies inducible ischaemia using gadolinium-based contrast to assess myocardial blood flow before and after administration of a pharmacological vasodilator. The blood flow should increase 3 to 5 times in areas supplied by normal coronary arteries, whereas little change occurs in areas supplied by diseased arteries, as their arteriolar beds are already maximally vasodilated. This results in delayed uptake of contrast.(26)

The risk of acute coronary syndrome is increased during the peri and postoperative period.(27) In addition to detecting areas of established myocardial injury, MRI has the ability to detect acute ischaemia, through the identification of myocardial oedema.(28) Along with traditional electrocardiogram and cardiac enzyme changes, this novel area of cardiac MRI is likely to have an increasing role in the assessment of possible acute coronary syndrome.

Cardiac imaging for cardiac surgery

In this section we will look at two areas of imaging related to conditions that necessitate cardiac surgery, namely valve imaging and coronary artery bypass grafts.

Cardiac valve assessment

Echocardiography is the most common method for non-invasively imaging cardiac valves. Standard 2D echocardiography provides information about valve morphology and function, as well as ventricular function and chamber size. Doppler ultrasound can be used to assess flow through valves and quantify the degree of stenosis and/or regurgitation. Furthermore, Doppler equations are often the basis of calculating valve area.

As previously discussed, 2D TOE is nearly always required in the assessment of mitral valve pathology due to the complex structure of the valve. The specific dysfunctional "scallop" within the anterior or posterior mitral leaflet can be identified, as well as the category of defect. For example, the surgical management of mitral valve prolapse is targeted differently to that of functional mitral regurgitation due to papillary muscle dysfunction.

3D echocardiography can be used to supplement 2D echocardiographic assessment of cardiac valves.

3D TOE can be used intraoperatively to provide the surgeon with more accurate anatomical information compared with 2D TOE, particularly for the mitral valve [29-30].

CT and MRI are infrequently used for valve assessment because echocardiography often answers all the clinical questions. However, inter-observer variability and restricted views limit the use of TTE. In such cases information from TOE, cardiac CTA and MRI may be helpful.

Contrast-enhanced CT provides a rapid assessment of valve anatomy with excellent spatial resolution. In particular the valve leaflet thickness and their movements can be clearly identified. Non-enhanced ECG-gated CT allows accurate assessment of valve calcification.(31-32) However the associated radiation limits its usefulness, particularly for serial assessment.

Whilst MRI can provide anatomical information, it has an inferior spatial and temporal resolution compared with echocardiography, as well as being more expensive and time consuming. One of the benefits of MRI is it can provide accurate information about the effects of valve disease on the related cardiac chambers, such as the ejection fraction and cardiac volumes. These factors are important for determining when surgical intervention for valve disease is required.

Finally, X-ray angiography is an important part of pre-operative assessment for valvular pathology. Firstly, left heart catheterisation provides an invasive assessment of pressure gradients across the valve in question, and left ventriculography or aortography allows visualisation of stenosis and/or regurgitation under contrast. Secondly, the coronary arteries are imaged, so that any necessary bypass grafting can be performed at the time of valve surgery.

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Cardiac imaging for the surgical trainee.
Cardiothoracic & Critical Care.

Knowledge of the degree of ischaemic heart disease also feeds into pre-operative risk stratification for the surgeon and the anaesthetist. Finally, for mitral and right-heart valve conditions, right-heart catheterisation (via the femoral vein) is also performed to allow determination of pulmonary artery and pulmonary capillary wedge pressures.

CTA for Coronary artery bypass grafts (CABG)

Post-operative CABG imaging can be used to assess graft patency in patients who experience angina or have a MI. Accurate assessment is important because it relates closely to clinical outcome.

Whilst x-ray angiography is the gold standard, it is an invasive procedure with associated risks, and a high contrast load and radiation dose can be required for full graft visualisation. CTA allows an accurate non-invasive alternative for assessing CABG patency.(3) However, CTA is not suitable for all patients, such as those with atrial fibrillation. Furthermore, due to artefact from metallic surgical clips and the typically advanced CAD and calcification in native vessels in these patients, exclusion of a significant graft stenosis or assessment of native coronary arteries can be difficult. There is therefore a continuing role for x-ray angiography in these patients.

CTA has a role in planning 'redo cardiac surgery'. Adhesions, loss of normal tissue planes and the risk of injury to patent grafts and native vessels make revision CABG surgery challenging. CTA provides detailed 3D images of the mediastinum and an accurate assessment of patent grafts, which can assist in the planning of such surgery. CTA is superior to traditional preoperative assessment with CXR and cardiac angiograms. Indeed, information from the preoperative Cardiac CT leads to a modified surgical strategy in 20% of patients undergoing 'redo cardiac surgery', helping to reduce morbidity.(34)

Conclusion

Understanding cardiac disease is important to both cardiac and non-cardiac surgeons. Developments in cardiac imaging are providing increasingly detailed assessment of the morphology and function of the heart. An appreciation of the various imaging modalities will help the surgical trainee understand the usefulness of different investigations for their patients.

Questions

1. Which of the following features is NOT commonly seen on a chest X-ray in pulmonary oedema?

A. Septal lines
B. Lower lobe venous diversion
C. Peri-hilar oedema
D. Cardiomegaly
E. Pleural effusion

2. Which of the following patient factors can render echocardiography inconclusive?

A. Pleural effusions
B. Obesity
C. COPD
D. Poor patient mobility
E. All of the above

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3. Which of the following modalities can assess for reversible myocardial ischaemia?

A. Chest x-ray
B. Coronary CT angiography
C. Transoesophageal echocardiography
D. X-ray coronary angiography
E. Dobutamine stress echocardiography

4. Which of the following investigations is NOT usually performed in a patient with mitral regurgitation prior to surgical referral?

A. Chest x-ray
B. CT coronary angiography
C. Cardiac catheterisation and coronary angiography
D. Transthoracic echocardiography
E. Transoesophageal echocardiography

5. Which of the following is NOT a recognised complication of cardiac catheterisation?

A. Myocardial infarction
B. Contrast reaction
C. Acute hepatic failure
D. Femoral artery pseudoaneurysm
E. Ventricular fibrillation

Answers

1. B.

The common abnormality seen is upper lobe venous diversion.

2. E.

Ultrasound beams cannot penetrate large layers of subcutaneous fat and disproportionate volumes of air or fluid within the thoracic cavity can also obscure cardiac anatomy. Furthermore echo relies upon obtaining images from various different angles, so if the patient cannot mobilise onto or around the scanning bed, it is usually impossible to obtain high quality images and accurate cavity or Doppler measurements. This highlights the importance of appropriate patient selection in order to prevent a non-diagnostic study from being obtained.

3. E.

Coronary angiography provides anatomical but not functional information about stenosed arteries. TOE can show regional wall motion abnormalities related to a specific vessel territory, but does not allow differentiation between irreversibly scarred myocardium and inducible ischaemia. Stress echo allows the comparison of wall motion pre- and post-inotrope administration. If there is a difference, perfusion may be restored by revascularising the relevant vessel territory.

4. B.

Patients undergoing cardiac surgery should all have had a baseline ECG, chest X-ray, spirometry and transthoracic echo. In mitral regurgitation, the exact mechanism for valvular incompetence needs to be demonstrated, as well as the specific segment and leaflet. This is almost always impossible without TOE. Coronary angiography is important in anybody undergoing cardiac surgery, and the gold standard for this is cardiac catheterisation. In addition, this allows measurement of right and left heart pressures and it is therefore preferable to CT.

5. C.

Angiography carries several risks which must be weighed up against possible benefits for individual patients. Contrast reactions and nephropathy are relevant, and the operator may select a different agent or limit contrast volume in cases with renal dysfunction. Vascular complications are common. They occur less at the radial artery, but at the expense of more challenging catheter manipulation and increased arterial spasm. MI and stroke can also occur, as can VF, especially during inadvertent injection of contrast into the conus branch of the right coronary artery.

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TESTICULAR TORSION: A UROLOGICAL EMERGENCY

M Cumberbatch

Testicular Torsion:
A Urological Emergency.
Urology.

Case Study

You are the CT1 on the surgical admissions unit. A 12-year-old boy is brought into the department. Following a game of football he has complained of severe right testicular pain. He has also vomited a couple of times. On examination he has an acutely tender right hemiscrotum. What is your diagnosis? How will you manage this patient?

Epidemiology

Testicular torsion can occur at any age but has a bi-modal distribution.(12) The main peak is at puberty (12-18 years) and a smaller peak in the first year of life.

Aetiology

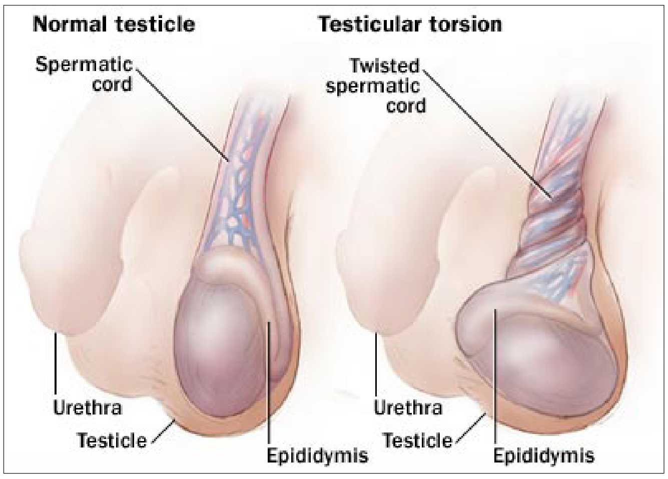
The risk factors for testicular torsion are undescended testis and testicular trauma. The commonest torsion is 'Intra-vaginal'. This is due to a congenital high investment of the tunica vaginalis on the spermatic cord, resulting in a horizontal lying testis known as "Bell-clapper".(2) It occurs in 12% of the male population. It is commonly bi-lateral.

In neonates, the aetiology tends to be 'Extra-vaginal' torsion. The testis and tunica vaginalis is loosely adherent to the scrotum i.e. incomplete fixation of gubernaculum to the scrotum.

Complete torsion occurs when the testis rotates around 360 degrees or more. The resultant damage occurs through ischaemia of the testis due to pathological occlusion of the vasculature resulting in venous congestion and arterial compromise. There is a positive correlation between how tightly the testis is twisted and how quickly it becomes non-viable.(2)

Presentation

The presentation of testicular torsion is one of acute unilateral orchalgia. This may be precipitated by an event such as trauma and exercise.



Signs

Examination may reveal a swollen hemi-scrotum. The testis may be high-riding testis wit a horizontal lie. The testes may feel tense and will be exquisitely tender on palpation. Ther may be loss of the ipsilateral cremasteric reflex, although presence of this reflex doesn't rule out torsion.(3)

Testicular torsion as seen on examination. The patient's left testis is acutely swollen and inflamed. This patient needs urgent surgical intervention.(4)

Important differentials

A comprehensive list of differential diagnoses for torsion would include:

- Acute epididymo-orchitis.
- Mumps orchitis.
- Testiscular tumour (bleed into a tumour).
- Torsion of hydatid of Morgagni
- Idiopathic Scrotal Oedema (< 10 years of age).

Each of these potential diagnoses has its own unique features that should enable the clinician to determine which is most likely.

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Epididymo-orchitis usually follows a less acute course than torsion with pain and swelling over a few days. The patient may have urinary symptoms and pyuria on urine dipstick.(3) It often occurs in men aged 18-50. In younger patients, a history of sexually-related infections, namely Chlamydia Trachomatis or Neisseria Gonorrhea is not uncommon. In older males, E.Coli is the commonest infective organism following a urinary tract infection.

Testicular rupture can occur following direct blunt or penetrating injuries. Penetrating trauma is most obvious and presents immediately. Blunt injuries may present following the development of a haematoma.

Testicular tumours commonly present as a painless, hard, nodular lump.

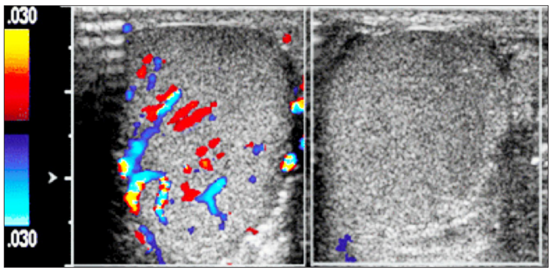
Torsion of the hydatid of Morgagni is the principle diagnosis of exclusion in male infants. Usually, the pain is localized to the upper pole of the testes and there is less swelling than with testicular torsion. The 'blue dot sign' may be present. In such cases, a conservative management approach can be considered but if there is any doubt then diagnosis is made at surgery.(2)

Patients with ureteric colic may complain of pain radiating from loin to groin but testicular signs are often absent.

Investigations

Testicular torsion is a clinical diagnosis. Urine analysis and radiological investigations are often unhelpful and should be avoided. Testicular Doppler Ultrasound may aid diagnosis in equivocal cases, revealing the absence of arterial supply to the testis.

Salvage rates of the testis is related to the number of hours of onset of pain. Most testis are salvaged within 6 hours of the onset of pain, very few survive with a history greater than 24 hours.



Doppler Ultrasound study of testicles. It shows an avascular left testis as found in torsion.

Management

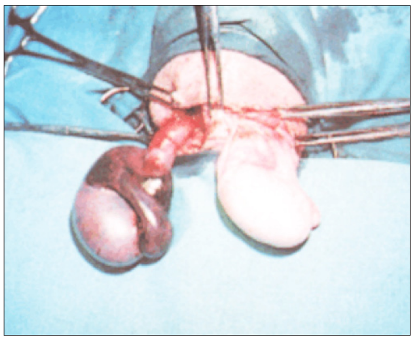
Testicular exploration is a surgical emergency and delay of surgery must be minimised.

The testis is approached trans-scrotal using a midline incision. The testis is then examined. At this point there are a number of possible findings:

- No torsion - The testis is left alone and the scrotum closed.

- Torsion present – detort and assess for viability (pink and warm). If dusky, then apply warm saline swabs for 15 minutes.(5) If the viability is still dubious then stab incisions of tunica albuginea using the scalpel to assess bleeding. If viable then perform a bilateral orchidopexy.

- If the testis is non-viable then perform a unilateral orchidectomy and contra-lateral orchiopexy.



[4]Testicular torsion as seen at surgery. The testis on the left has infracted leaving a necrotic looking testis in comparison to the viable testis on the right.

Consenting the patient(6)

The key points to mention when consenting a patient for scrotal exploration +/- orchidectomy/orchidopexy are:

- Scrotal haematoma
- Infection
- Removal of testis
- Negative findings
- Delayed testicular prosthesis insertion (increased erosion rates)

TESTICULAR TORSION: A UROLOGICAL EMERGENCY

M Cumberbatch

A guide to performing an Orchidectomy or Orchidopexy(7, 8)

Orchidectomy

- Step 1: Anaesthesia. This procedure may be performed under local, regional or general anaesthetic.
- Step 2: Anterior scrotal wall is shaved and prepared in a sterile manner.
- Step 3: 2-3cm midline incision along the median raphe. The assistant should push the testis towards the incision.
- Step 4: The incision is then carried down through the dartos and cremasteric layers to the parietal part of the tunica vaginalis. Usually evidenced by a gush of peri-testicular fluid.
- Step 5: Lengthen the incision enough to expose the entire testicle through the wound.
- Step 6: Surrounding tunics are dissected away and haemostasis achieved.
- Step7: Spermatic cord is isolated and the vas

separated, doubly clamped and divided and ligated.
- Step 8: The other cord structures are also then ligated.
- Step 9: Once haemostasis is confirmed, the cord is allowed to retract.
- Step 10: Deep layers are closed and then the skin.
- Step11: Gauze dressing applied. Compression dressings can be used if there is concern regarding haemostasis or oedema.

Orchidopexy

This procedure is performed much the same as above until step 6, at which point the testis is managed by 3 point fixation of the testis to the scrotal wall using non-absorbable sutures.(1)

Conclusions

Testicular torsion is a Urological emergency requiring urgent action. If managed well complications can be successfully avoided. The key principles are to rule it out in any male presenting with abdominal pain, to recognize it early, to work quickly and to explore the scrotum if in any doubt. One should always contact the urologist on-call.

Questions

1. If testicular torsion is the most likely diagnosis in a patient with an acute scrotum, the investigation of choice is?

a. To perform a doppler ultrasound scan
b. To explore the scrotum surgically
c. To perfom a urine dipstick

2. What names are given to the types of torsion?

a. Intravaginal and Extravaginal
b. Intra-abdominal and Extra-abdominal
c. Complete and Incomplete

3. For torsion to be complete, how many degrees of rotation must there be?

a. 90°
b. 180°
c. 360°

4. The 'blue dot sign' is used to differentiate between?

a. Testicular torsion and Epididymitis
b. Testicular torsion and Tumours
c. Testicular torsion and Torsion of Hydatid of Morgagni

5. If the testis is of dubious viability, it may be wrapped in warm saline. For how long should this be done?

a. 1 minute
b. 15 minutes
c. 1 hour

Answers

1. b 2. a and c 3. c 4. c 5. b

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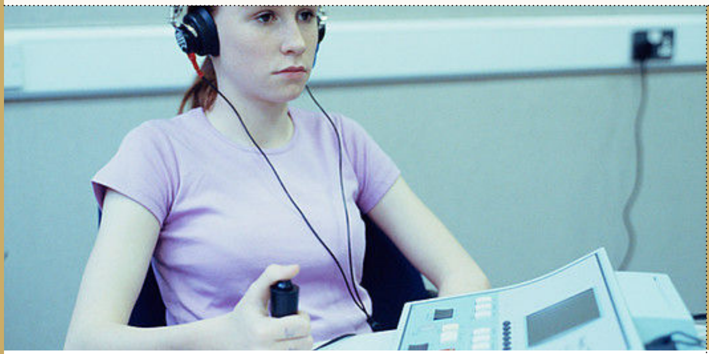
PURE TONE AND IMPEDANCE AUDIOMETRY FOR SURGICAL TRAINEES

J Risley, R Frear, D Farr and M Kurian



Pure Tone and Impedance Audiometry for Surgical Trainees. Otorhinolaryngology & Neck Surgery.

The first time most doctors encounter pure tone audiometry (PTA) would be during the one or two weeks allocated during their medical school training, and thus retaining the knowledge gained at this point can present quite a challenge. The next time that many would then encounter a PTA would most likely be as the ENT SHO in the emergency clinic, or in a formal outpatient clinic setting, where they will be expected to interpret them.

The audiogram can be an extremely useful tool providing a wealth of data to aid your clinical history and examination. However extracting this information from the graph presented to you can be a bit tricky to those unfamiliar with audiograms and their interpretation.

The aim of this article is to provide a basic understanding of audiograms, some examples and the possible associated underlying pathology. We will also touch on tympanometry and stapedial reflexes, and their clinical relevance. I would like to stress that this is only a basic outline in order to aid interpretation and clinical decision making. The physiological principles underlying hearing and audiology are more complex than the scope of this article.

Pure Tone Audiometry

Put simply, the aim of the test is to examine the conduction of sound via the auditory pathway to the vestibulocochlear nerve, via both air and bone conduction, and to see whether there is a difference between the two.

Audiometry should always be preceded by otoscopic examination to ensure that the canals are patent (for example not full of wax, or oedematous due to otitis externa) to ensure that a false air-bone gap is not measured. Therefore always remember to check for this prior to requesting an audiogram or sending a patient to audiology.

Air Conduction

This essentially is a test of how well sound (ie a tone) travels via the ear canal and middle ear components of the auditory pathway, and is tested first.

Earphones are placed on the patient, and tones of various frequencies are presented ranging from between 250Hz and 8000Hz. Vibrotactile perception can occur at frequencies outside this range, which can lead to a false positive result – i.e. the patient interprets feeling the vibration of the tone as hearing, rather than actually hearing it.

A tone is presented for a variable duration of between 1 and 3 seconds. The tone is presented at various intensities (ie the 'loudness', measured in decibels), and the lowest intensity that the patient can hear is recorded and plotted on a graph.[1]

If a hearing loss is detected at this stage it could represent a problem affecting any part of the auditory pathway, from the external auditory canal to the vestibulocochlear nerve and central pathways.

Bone Conduction

Bone conduction will be tested only if there is a hearing loss detected via air conduction, and will allow differentiation between a conductive hearing loss and a sensorineural hearing loss. Bone conduction acts to bypass the ear canal and middle ear apparatus, and stimulate the cochlea directly.

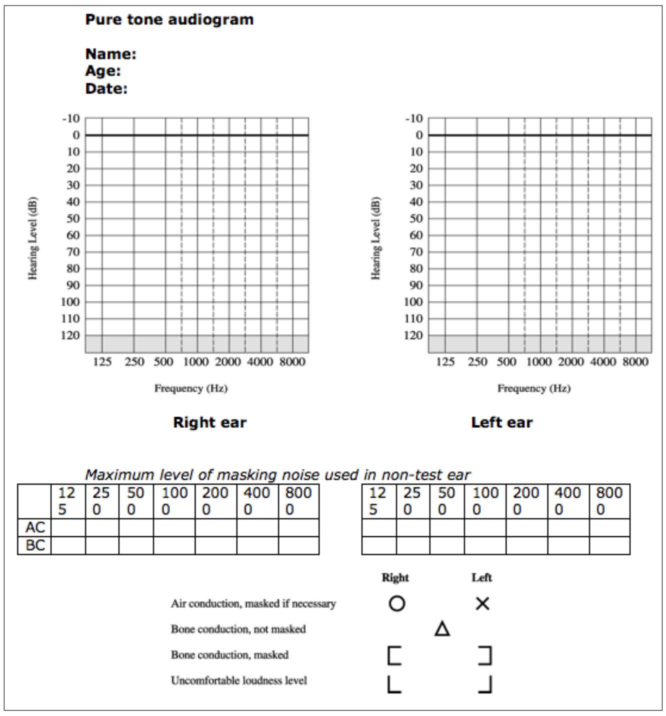
A bone vibrator is placed over the mastoid prominence, and a similar testing method is applied as for testing air conduction. The vibrotactile threshold may be lower when using a bone vibrator, and care must again be taken for the patient not to misinterpret vibrotactile perceptions as hearing.[1] In essence, the tone passes directly to the cochlea, transmitting the sound via the temporal bone and bypassing the middle ear.

If bone conduction is normal, or reduced but to a lesser extent than the air conduction, this suggests that the cause of the hearing loss is related to either the external auditory canal or the middle ear, and is thus termed a 'Conductive Loss'. However, if there is an associated reduction in bone conduction to the same degree as the air conduction loss (or within 10dB), then this must be related to cochlea and retrocochlear pathways and is thus termed a 'Sensorineural Loss'.

PURE TONE AND IMPEDANCE AUDIOMETRY FOR SURGICAL TRAINEES

J Risley, R Frear, D Farr and M Kurian

The results of these two tests are plotted and demonstrated on the audiogram, as shown below in figure 1. A normal audiogram is demonstrated in figure 2.



Reference : British Society of Audiology Recommended procedure (March 2004). Pure tone air and bone conduction threshold audiometry with and without masking and determination of uncomfortable loudness levels.

Figure 1: Recommended format for audiogram forms.

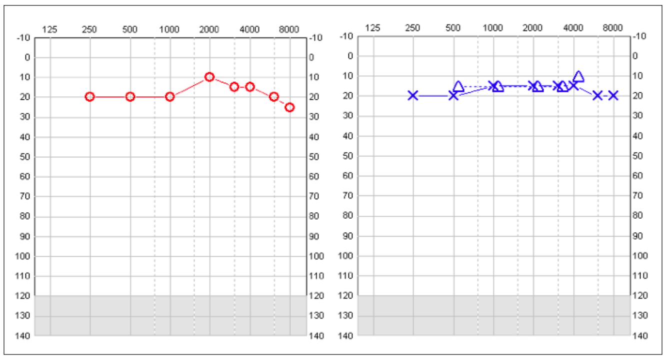


Figure 2: Normal hearing

Right ear - hearing within normal range.

Left ear - hearing within normal range.

Masking

Although earphones allow sound to be presented to one ear at a time, it is possible that the non-test ear is the one actually detecting the sound. When the level of hearing between the ears is very different, it is possible that when testing the worse ear, the better 'non test' ear detects the test signals more easily despite the fact that the signals reaching it are attenuated; hence a false-positive result is achieved and the level of hearing in that ear appears better than it actually is.[1]

To prevent this happening, a masking noise is presented to the non-test ear at the appropriate intensity to prevent it from detecting the test signals being presented to the tested ear. The results of this are also represented on the audiogram.

Interpretation of PTA

Most people should have a hearing 'threshold' of around 20db. Hence throughout all the tested frequencies, a patient with 'normal' hearing should be able to hear the tone presented at an intensity of 20db or less. If a tone is required to be presented at a higher intensity, ie louder than 20dB, then the patient is said to have a degree of hearing loss at that frequency. Hearing loss is broadly classified as:

Mild:	**20-40 dB loss**
Moderate:	**41-70 dB loss**
Severe:	**71-95 dB loss**
Profound:	**In excess of 95 dB loss[1]**

A hearing loss can be a 'normal' physiological loss. For instance with presbyacusis, where it is normal for people to lose hearing at the higher frequencies as they age. However, in many cases there is underlying pathology which could possibly be rectified.

Hearing loss can thus be described as either Conductive, Sensorineural, or Mixed. Causes and examples of audiograms along with explanations are outlined on the next page.

PURE TONE AND IMPEDANCE AUDIOMETRY FOR SURGICAL TRAINEES

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Pure Tone and Impedance Audiometry for Surgical Trainees.
Otorhinolaryngology & Neck Surgery.

Conductive Hearing Loss

Conditions to consider would be conditions affecting the ear canal, myringo/tympanosclerosis, tympanic membrane perforation, otitis media with effusion, and otosclerosis. Examples of audiograms relating to the above are shown below in figures 3, 4 and 5.

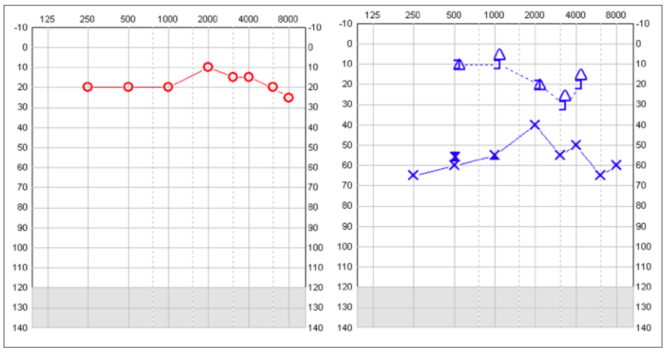

Figure 3: Conductive hearing loss

Right ear - within normal range.
Left ear - moderate conductive hearing loss. Even when masked, the bone conduction on the left side is largely normal.

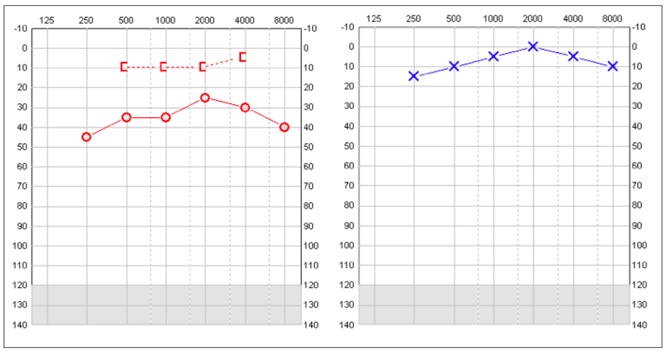

Figure 4: Conductive hearing loss

Conductive loss consistent with Secretory Otitis Media or 'Glue Ear' on right side.

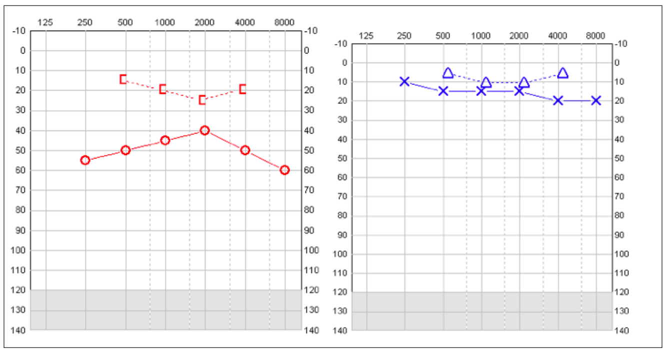

Figure 5: Otosclerosis

An audiometric finding characteristic of otosclerosis is an increase in bone conduction threshold with a peak at 2,000 Hz known as Carhart's notch.

Right ear – Otosclerosis – the 'notch' is apparent at 2000Hz
Left ear – normal hearing

Sensorineural Hearing Loss

Conditions to consider include presbyacusis, noise-induced hearing loss, and acoustic neuroma. Examples of audiograms relating to the above are shown below in figures 6-11.

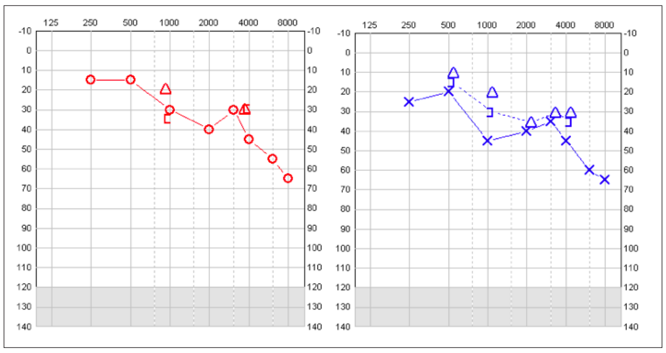

Figure 6: Sensorineural hearing loss

Right ear - mild sensorineural hearing loss.
Left ear - mild sensorineural hearing loss.

In the right ear, the unmasked bone conduction at 1000Hz may give the impression that they have a threshold within normal limits, but when masked it can be seen that the threshold is 15dB lower at 35dB.

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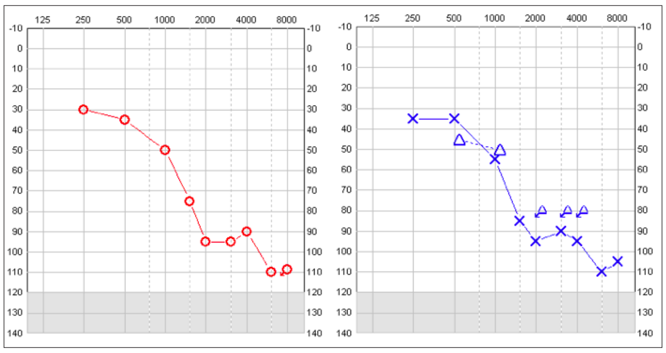

Figure 7: Sensorineural hearing loss

Right ear - severe high frequency sensorineural hearing loss.

Left ear - severe high frequency sensorineural hearing loss.

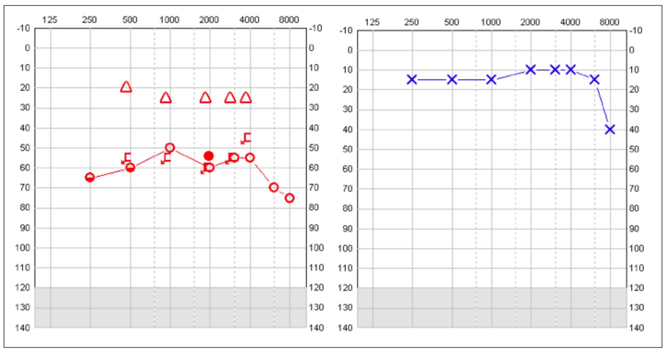

Figure 8: Sensorineural hearing loss

Right ear - moderate sensorineural hearing loss.

Left ear - within normal range.

On the right side, the unmasked bone conduction might initially present a picture of a conductive loss. However, when masked it can be seen that the thresholds are actually 30dB lower, and hence it is indeed a sensorineural loss – the patient has initially interpreted the sound in the non test ear (which has normal hearing) as being relieved in the test ear. Masking eliminates this problem.

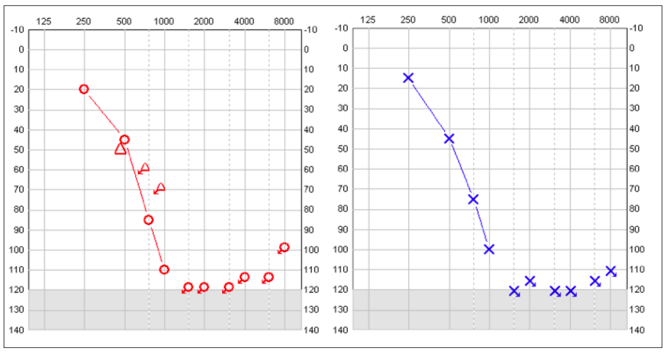

Figure 9: Sensorineural hearing loss

Right ear - severe sensorineural loss.

Left ear - severe sensorineural loss.

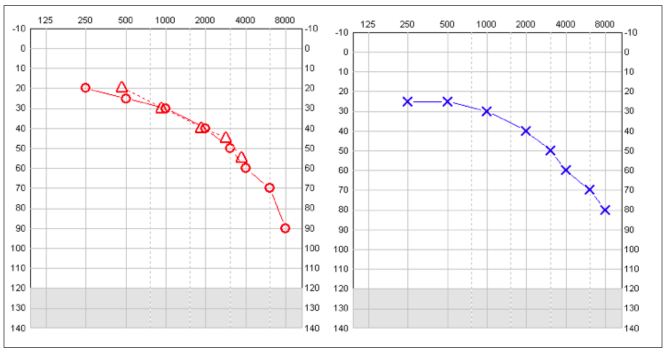

Figure 10: Presbyacusis

Typical example of a patient with bilateral presbyacusis. It is important to correlate this clinically, however this pattern of hearing loss is consistent with ageing.

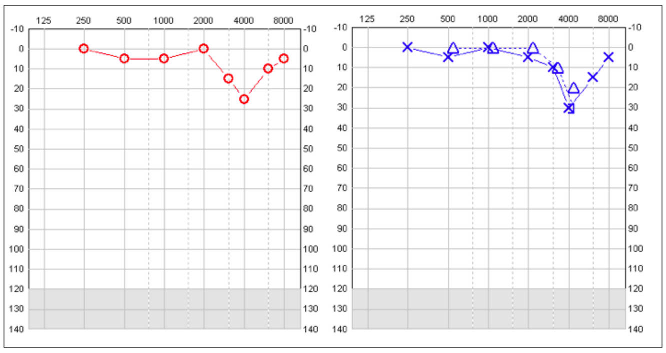

Figure 11: Noise induced hearing loss.

A sensorineural hearing deficit that begins at the higher frequencies (3,000 to 6,000 Hz) and develops gradually as a result of chronic exposure to excessive sound levels. Although the loss is typically symmetrical, noise from such sources as firearms or sirens may produce an asymmetric loss. A dip on the audiogram at around 4000Hz is characteristic.

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Mixed Hearing Loss

The bone conduction thresholds, whilst not within the normal range, are less elevated than the air conduction thresholds. An example is shown below in figure 12.

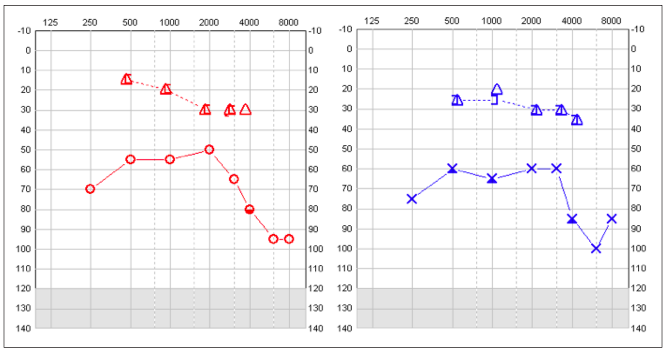

Figure 12: Mixed hearing loss
Right ear - moderate mixed hearing loss.
Left ear - moderate mixed hearing loss.

Tympanometry and Stapedial reflexes

These form the basis of Impedance Audiometry. Again the physics and mechanics underlying this are more complex than the scope of this article. However, this is essentially a measure of the mobility of the tympanic membrane and the pressure in the middle ear. It relies on acoustic compliance, which is a measurement of the amount of sound absorbed by the middle ear system.[2]

An air-tight seal is formed with the external auditory meatus, and a pressure wave is sent down the canal. The reflected sound energy can allow measurements of acoustic impedance and compliance to be derived, as well as middle ear pressure.

The compliance, which is the amount of sound absorbed by the middle ear, can be determined either by measuring the reflected sound level in the ear canal, or by measuring the amount of energy required to keep the sound level constant at varying ear canal pressures. The compliance will be maximal when the ear canal pressure is equal to the middle ear pressure, i.e. when there is no pressure difference across the tympanic membrane.[2]

Ear canal volume can also be measured. A large canal volume signifys a perforation of the tympanic membrane.

In tympanometry, compliance is measured continuously while pressure in the EAM is varied from +200 to -400mm H20. This gives a graphical result which is outlined below.

Three patterns are typically seen:

Type A: Maximal compliance occurs when then the pressure in the EAM is between +50 and -100mm H20. A low value for maximal compliance indicates stiffness of the middle ear, such as tympanosclerosis or otosclerosis. A high peak indicates excess mobility of the middle ear system such as ossicular discontinuity.[3]

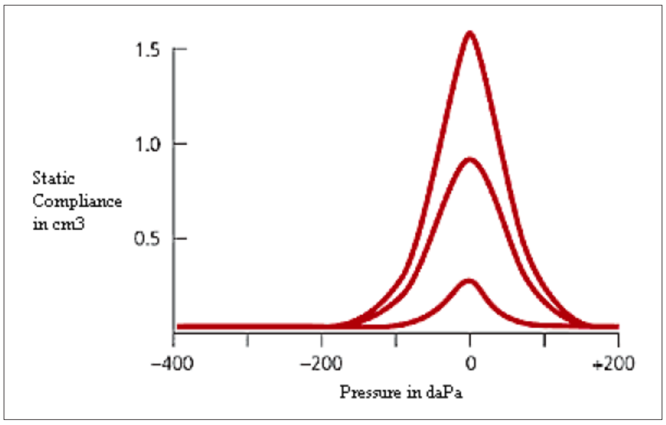

Figure 13: Type A tympanogram.
High and low peaks are also demonstrated.

Type B: A horizontal trace is seen indicating persistently low compliance, usually indicating fluid in the middle ear (OME). It would also be seen with a tympanic membrane perforation, though the ear canal volume will be large also (>6ml) – in OME the canal volume would be normal.[3]

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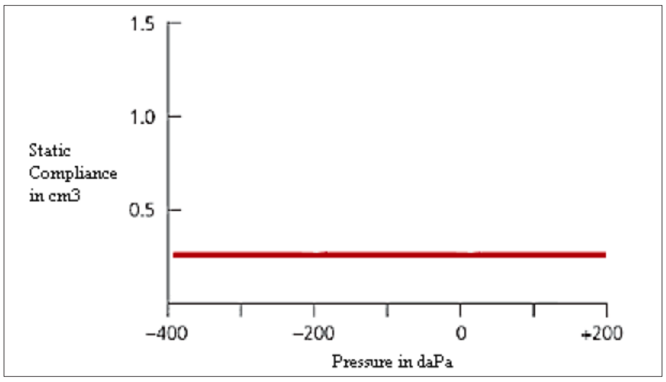

Figure 14: Type B tympanogram.

Type C: A similar graph to type A, however shifted to the left demonstrating negative pressure in the middle ear, consistent with eustachian tube dysfunction.[3]

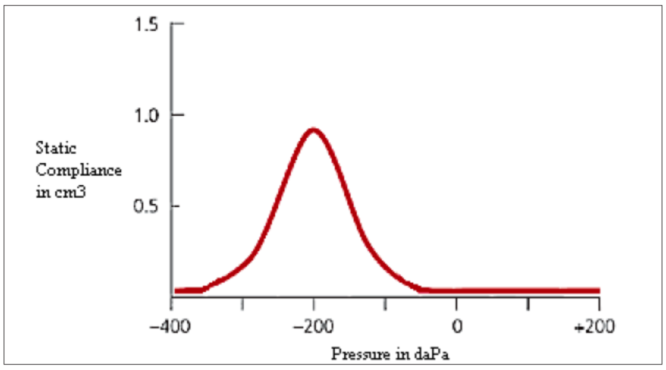

Figure 15: Type C tympanogram.

When used in conjunction with an audiogram, it can be seen that tympanometry provides very useful information. For instance a patient with a conductive loss and a type B tympanogram would lend towards a diagnosis of OME, however a patient with a conductive loss but type A tympanogram may suggest otosclerosis. It can thus aid diagnosis, clinical decision making and management.

Stapedial Reflexes

This occurs when the stapedius muscle contracts in relation to a loud sound. This leads to a stiffening of the ossicular chain and the tympanic membrane, and thus decreases compliance. This change in compliance can be measured and recorded as a representation of the stapedial reflex. They usually occur at around 70-90dB.[4]

Reflexes are absent in the presence of a severe or profound sensorineural hearing loss. A moderate conductive hearing loss may also eliminate the reflex, as the middle ear pathology (such as otosclerosis or effusion) prevents the stapedius muscle from contracting. In pathology affecting the facial nerve, the reflex can help determine whether the lesion is proximal or distal to the branch of the stapedius muscle. If the lesion is proximal to the stapedius reflexes are absent; if the lesion is distal to the muscle then the reflexes are present.[4]

Summary

Both pure tone and impedance audiometry are invaluable to the ENT clinican, aiding diagnosis and management. Hopefully this article has provided a brief insight in order to understand the basic principles behind them. Further reading is encouraged for ENT trainees.

References

1. British Society of Audiology Recommended procedure: Pure tone air and bone conduction threshold audiometry with and without masking and determination of uncomfortable loudness levels. March 2004.

2. Recommended procedure for tympanometry, British Journal of Audiology, 1992, 26, 255-257

3. Key topics in Otolaryngology 2nd edition, NJ Rowland, RDR McRae, AW McCombe.

4. Current Diagnosis and Treatment in Otolaryngology - Head and Neck Surgery: Second Edition (Lange Current Series), Anil Lalwani.

Questions

The following are components of the auditory pathway, true or false:

a. Superior olivary nucleus
b. Medial geniculate body
c. Inferior colliculus
d. Cochlear nucleus
e. Trapezoid body

Answers

a. True b. True c. True d. True e. True

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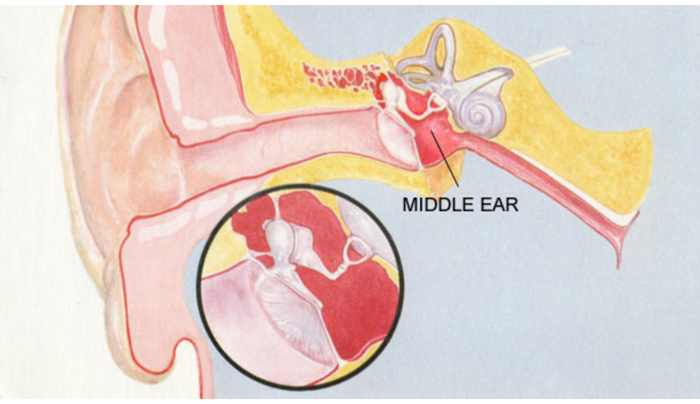
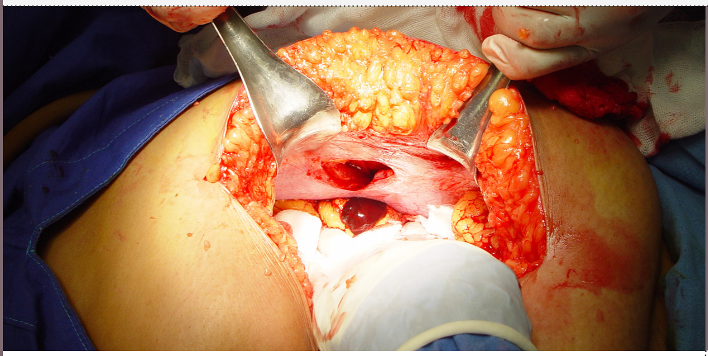


MANAGEMENT OF THE SICK SURGICAL CHILD

G Shepherd



Management of the Sick Surgical Child.
Paediatric Surgery.

You are called to the surgical ward to see a 9 month old boy who 2 days previous had a laparotomy and small bowel resection for intussusception. He has been more lethargic over the last 1 hour, has had 30ml/kg yellow aspirates up his NG tube over 24 hours and a urine output of 0.5ml/kg/hr for the last 4 hours:

1. What immediate factors must be assessed first?
2. What initial intervention would you do?
3. What additional information might you need to diagnose the cause to enable initiation of definitive treatment?

Introduction

As with adults, the outcome of cardiac arrest in children is poor. Therefore early recognition and management of potential respiratory, circulatory or central neurological failure will reduce mortality and secondary morbidity.

The most important principle is to have a systematic approach so that nothing is missed. An excellent format to follow is that of the Care of the Critically Ill Surgical Patient (CCrISP) course with a few tweaks for paediatrics.

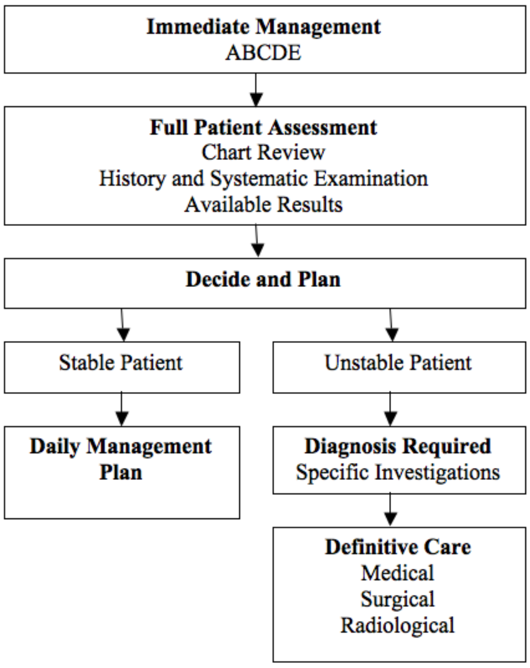


Fig 1: CCrISP system of assessment

In general there are 2 types of sick surgical patients. The first group includes the newly admitted and those who have suffered an acute deterioration on the ward. They often need simultaneous resuscitation, investigation and definitive treatment.

Then there is a second group who are already on the ward or in an HDU environment who need reassessment and formulation of a management plan to ensure continuing progress in their recovery. Failure to progress is an important sign of impending deterioration. If this can be spotted early on and intervention implemented, then morbidity and mortality can be prevented or reduced. If however this problem is not diagnosed until it has produced a major deterioration in the patient's condition, the patient's morbidity and mortality is increased.

A systematic approach reduces the chance of missing vital warning signs so that potentially life-threatening conditions are not overlooked. One such systematic approach is demonstrated in Fig 1.

Immediate Management

The goal of managing a sick surgical patient is to establish what is making the patient sick so that definitive treatment can be implemented immediately. The majority of life-threatening processes kill in a predictable and reproducible manner. Illnesses that compromise the airway kill before those that cause lung dysfunction which in turn kill before those that cause circulatory collapse. As such the principle of assessing and treating ABCDE in that order has been highly successful in identifying and reversing immediate life-threatening processes so that more definitive care can be provided. Experience tells us however that disease rarely affects biological systems in isolation, but affects multiple vital systems at once and so a full assessment is always required.

The process of assessing ABC can be a very quick one, achieved in less than a minute once a system has been adopted (Fig 2). On initial contact a lot of useful information can be gathered from the end of the bed. A child that is crying for their mummy is maintaining his own airway, ventilating his lungs, has a sufficient circulatory system to perfuse his brain to support a GCS close to 15. A playing child is unlikely to have any immediately life-threatening process affecting them (but this does not preclude significant disease).

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However, the quiet child who lies still in his bed, refusing to play despite ample toys is of greater concern. These children can be overlooked by busy ward staff whose attention is focussed on the crying, noisy, disruptive or playing child. An in-depth explanation and example of assessment of ABC will not be reproduced here as there are many sources of this on various courses.

Rapid Clinical Assessment of an Infant or Child

- Airway and Breathing
  - Effort of breathing
  - Respiratory rate/rhythm
  - Stridor/wheeze
  - Auscultation
  - Skin colour
- Circulation
  - Heart Rate
  - Pulse volume
  - Capillary refill
  - Skin temperature
- Disability
  - Mental status/conscious level
  - Posture
  - Pupils

Once A,B & C are clearly recognised as being stable or have been stabilised, then definitive management of the underlying condition can proceed. During definitive management, reassessment of ABCD at frequent intervals will be necessary to assess progress and detect deterioration.

Figure 2 (APLS)

When assessing a child's vitals, one must be familiar with the normal ranges for different ages. Care should be taken in interpreting one-off measurements, as these rates vary greatly with activity, Trends are a far more useful guide as an indicator of deterioration or improvement. (Fig 3).

Fig 3 Vital Signs (Approximate normal ranges)

Age (yrs)	Respiratory rate (breaths/min)	Pulse (beats/min)	Systolic BP (mmHg)
<1	30-40	110-160	65-90
1-2	25-35	100-150	70-95
2-5	25-30	95-140	70-100
5-12	20-25	80-120	80-110
>12	15-20	60-100	90-120

Figure 3

If any intervention is made during the immediate management, be it an airway-opening manoeuvre or a fluid bolus, an assessment of the response should always be made. There are some important considerations when managing paediatric patients that should be born in mind.

IV access

Intravenous access in the hypovolaemic child can be a very challenging problem. In the emergency situation, early utilisation of the intraosseus route can be a life saving procedure. It is safe, efficacious and requires less time than a venous cutdown. Once boluses have been given it is then easier to gain access to the more adequately filled veins. The preferred site is the proximal tibia below the tibial tuberosity.

Urinary Catheterisation and Urine Output in Children

A child should only be catheterised if they cannot pass urine spontaneously or if strict continuous measurement of urine is required for stabilisation of the shocked patient. This may be urethral or suprapubic depending on the situation. The urine output in children varies with age. Not until a child stops growing does the expected urine output drop to 0.5ml/kg/hr. (Fig 4)

Nasogastric tube placement

Acute gastric dilatation is not uncommon in sick surgical or injured children and so the stomach should be decompressed if there is evidence of this. The tube should be aspirated regularly and left on free drainage between times. A distended stomach can hold many litres of fluid and cause significant splinting of the diaphragm, mimicking intra-abdominal pathology.

Analgesia

The value of adequate analgesia in aiding the assessment of a child is often overlooked. Analgesia does not hide clinically significant symptoms or signs, but it can help convert a frightened pain stricken uncooperative child into a relaxed compliant patient. This facilitates a more accurate reliable assessment of the child's clinical status.

Response to Haemorrhage

The paediatric patient, compared to the adult, has great physiological reserve with a phenomenal ability to compensate for severe insult. As a result, the degree of shock and dehydration is often underestimated. Blood pressure is rarely ever a useful measurement, as physiological compensation maintains arterial pressure up until the peri-arrest period. Therefore other clinical signs should be relied upon and never ignored because of the presence of a normal blood pressure. In the situation of haemorrhage, a child may lose up to 30% of their circulating volume before they exhibit any clinical signs. (Figure 4)

The aim of fluid resuscitation in children is to restore the circulating volume. In a child the total circulating volume is approximately 80ml/kg, increasing to 90ml/kg in the neonate. When shock is suspected fluid is given in 20ml/kg boluses of crystalloid (such as 0.9% saline or Hartman's Solution).

In surgical patients the cause may often be bleeding from trauma or surgery. Up to 3 boluses may be required because the 3-for-1 rule applies to children as well as adults, so 60ml/kg of fluid would be needed to replace a 20ml/kg circulatory volume deficit; this is due to equilibration with the interstitium.

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Blood products are preferred for replacing blood loss as this requires less volume and stays in the circulatory system minimising the adverse effects of large fluid shifts into the interstitium, as well as aiding oxygen delivery to the tissues. Patients have 1 of 3 responses to this. Either they respond to the fluid treatment, or they initially respond and then deteriorate (transient responder) or they do not respond. These last 2 groups usually require further blood and consideration for urgent definitive treatment such as an operation.

TABLE 10-3 ■ Systemic Responses to Blood Loss in Pediatric Patients

SYSTEM	MILD BLOOD VOLUME LOSS (<30%)	MODERATE BLOOD VOLUME LOSS (30%-45%)	SEVERE BLOOD VOLUME LOSS (>45%)
Cardiovascular	Increased heart rate; weak, thready peripheral pulses; normal systolic blood pressure (80-90 + 2 x age in years); normal pulse pressure	Markedly increased heart rate; weak, thready central pulses; absent peripheral pulses; low normal systolic blood pressure (70-80 + 2 x age in years); narrowed pulse pressure	Tachycardia followed by bradycardia; very weak or absent central pulses; absent peripheral pulses; hypotension (<70 + 2 x age in years); widened pulse pressure (or undetectable diastolic blood pressure)
Central Nervous System	Anxious; irritable; confused	Lethargic; dulled response to pain[1]	Comatose
Skin	Cool, mottled; prolonged capillary refill	Cyanotic; markedly prolonged capillary refill	Pale and cold
Urine Output[2]	Low to very low	Minimal	None

[1]The child's dulled response to pain with this degree of blood loss (30%-45%) may be indicated by a decreased response to IV catheter insertion.

[2]After initial decompression by urinary catheter. Low normal is 2 ml/kg/hr (infant), 1.5 ml/kg/hr (younger child), 1 ml/kg/hr (older child), and 0.5 ml/hg/hr (adolescent). IV contrast can falsely elevate urinary output.

Fig 4: (From ATLS Manual)

Full Patient assessment

The immediate management interventions are not an end in themselves. They are simply to keep the patient stable until you solve the underlying problem. Once the patient has been immediately stabilised, it is necessary to gather information to lead to a diagnosis of current or potential problems so that a plan of action can be reached.

Chart Review

Inspection at the end of the bed of the observation and fluid/feed charts with discussion with the nurse helps highlight any recent or outstanding problems to allow a more focused clinical assessment. Charts on HDU or ITU contain a lot of useful data but can vary in presentation from place to place and so one needs to know what information you want rather than relying on the chart to make the useful information obvious. (Fig 5) The drug card should be reviewed to assess if any new medications have been commenced or regular medications forgotten, as either can influence the patient's condition.

Fig 5 Useful Information from Charts (CCrISP p11)

R Respiratory:
- Respiratory Rate
- Inspired oxygen concentration (FiO2)
- Oxygen Saturation (SaO2)

C Circulation
- Heart rate and rhythm
- Blood pressure
- Urinary output
- Fluid balance
- IV lines
- CVP

S Surgical
- Drainage
- Temperature
- Special requirements of specific operation

Figure 5

History and Examination

As with all areas of clinical practice, a history of the patient's current illness and treatment is vital and the impact of comorbidity should never be underestimated. All available sources of information should be utilised. The patient, the family, the nursing staff and other professionals can all provide useful information. The insight and value of information provided by young children should not be overlooked. A three year old child who denies the presence of pain is usually more reliable than many adult patients who deny symptoms. A full systematic examination should be performed, paying particular attention to the vital systems and those areas involved by surgery or the underlying condition.

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This is a good time to review any wounds or stomas. The value and importance of repeated clinical examination cannot be overemphasised, both for detecting important clinical signs that are less likely to be missed and for providing an impression of clinical improvement or deterioration which is more reliable than a one off clinical impression. Available investigation results should now be reviewed (Fig 6).

Fig 6 Review of Results

Biochemistry
- Profile
- Glucose
- Capillary/arterial/venous blood gas

Haematology
- Blood count
- Clotting profile
- Group and Save or Cross Match available

Microbiology

Radiology
- Images and Reports

Figure 6

Stable or Unstable?

Having assessed the patient with all available information a basic decision needs to be made: is the patient stable or unstable? If there is uncertainty, then the patient is treated as unstable.

Stable Patients: Daily Plan

These patients have normal signs and progress as expected. Most patients on a daily ward round will fit into this category. While they may not need resuscitative measures, they will need a daily plan. (Fig 7)

Fig 7 Daily Plan

Investigations
- Bloods/ Imaging
- Specialist opinions

Removal of NG/catheter/drains?

Oral intake

Fluid balance and prescription

Nutrition
- Requirement
- Route

Physiotherapy

Drugs and analgesia (verify they have been given)
- Therapeutic (eg antibiotics, analgesia)
- Preventive (eg prophylaxis, immunisations)
- Routine (eg inhalers)

Move to lower level of care?

Communicate above to patient, family and nursing staff

Documentation of plan in notes

Figure 7

Unstable Patient

Further investigation or definitive treatment is required if progress after immediate care is not satisfactory. If evaluation has revealed a cause then treatment can be planned. Consider if the level of care is appropriate or if the patient needs moving to HDU or ITU, and if more senior help is needed.

It may be that resuscitation is required before further investigation commenced or it may need to be implemented simultaneously.

Specific investigations are utilised to figure out why the patient is unwell and unstable to enable intervention. These range in complexity and it may be that the results of any simple ones already performed, such as blood tests, may be back.

The more complex investigations need planning, and this will change depending on the test, the urgency of the situation and how unwell the patient is. The CT scanner is rarely a safe place for a sick patient without support from critical care medical and nursing teams. It may be that the test that will give the answer cannot be done because of the condition of the patient, or that transfer to ICU for implementation of supportive care is required before transfer to radiology.

Specialist opinions may be required from other specialities. Early discussion with your consultant should happen if progress is not being made either on a diagnostic or organisational front. It is not appropriate for a treatment or investigation to be postponed just because it is difficult to implement or it is a difficult time. Unstable patients rarely spontaneously improve at 4am.

Momentum should be maintained, as small delays at each step can result in a long delay in treatment of the underlying illness, rendering initial successful resuscitation in vain.

Definitive Treatment

The aim is to provide treatment as quickly as possible. The steps described keep the patient alive until the definitive treatment for the underlying problem is provided. If it is not, the patient will simply deteriorate again and eventually die.

Reassessment

Once any intervention or treatment has been implemented, it is essential to reassess the patient to gauge response. The length of time between treatment and reassessing depends on the urgency and nature of the situation. If the response is inadequate then it may be a different cause or treatment needs to be sought. Reassessment is always the final step, but it may also be the first step in repeating the whole process.

MANAGEMENT OF THE SICK SURGICAL CHILD

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References

Care of the Critically ill Surgical Patient Course 2nd Edition Royal College of Surgeons of England Hodder Arnold
APLS manual 5th Edition, Wiley-Blackwell Publishers
ATLS Manual 8th Edition, American College of Surgeons

Questions

1. A seven week old boy arrives in A&E lethargic and peripherally shut down. He has a 2 week history of nonbileous vomiting without a distended abdomen. He has not opened his bowels in a week and has not wet his nappy in 18 hours. Multiple unsuccessful attempts have been made at IV access during which the child did not cry. The ED doctor is concerned the child may have intussusception or pyloric stenosis and would like a surgical opinion.

a. Give the child high flow oxygen, gain intraosseous access, give a fluid bolus and assess the response, repeating if necessary; pass an NG tube and send blood samples for FBC, UE, CRP, Blood culture. An USS would be the most useful investigation for determining further management and investigation.
b. Give the child high flow oxygen, gain intraosseous access, give a fluid bolus and assess the response, repeating if necessary; pass an NG tube and send blood samples for FBC, UE, CRP, Blood culture. A capillary blood gas is the most useful investigation for determining further management and investigation.
c. Give the child high flow oxygen, gain intraosseous access, give a fluid bolus and assess the response on the way to theatre for an urgent laparotomy and repeat the bolus if necessary. Blood samples sent should include a crossmatch.
d. Give the child high flow oxygen, gain intraosseous access, give a fluid bolus and assess the response, pass an NG tube and urinary catheter and send blood samples for FBC, UE, CRP, Blood culture. A lumbar puncture would be the most useful investigation for determining further management and investigation.
e. Give the child high flow oxygen, gain intraosseous access, give a fluid bolus and assess the response, repeating if necessary; pass an NG tube and send blood samples for FBC, UE, CRP, Blood culture and a blood gas. An upper GI contrast would be the most useful investigation for determining further management and investigation.

2. The paediatric surgical ward calls you to see a 9 year old boy who is two hours post lap-converted-to open appendicectomy for a perforated gangrenous appendicitis which itself took two and a half hours. His heart rate has been creeping up to 125 since returning from recovery, his respiratory rate is 30, he is saturating 96% in 28% FiO2 and has a temperature of 38 degrees celsius. He is complaining of increasing abdominal pain. His urine output initially was 0.5ml/kg per hour preoperatively but has been 2ml/kg per hour since returning from theatre. His NG aspirates have been low and yellow in colour. He is written up for regular paracetamol, codeine orally and iv cefuroxime, metronidazole and gentamicin.

a. Carry out a full systems examination. Providing they are normal, give a fluid bolus as he is likely dehydrated from his prolonged operation.
b. Give a fluid bolus and crossmatch some blood. If he does not respond he will need to return to theatre as post operative bleeding is the most likely cause.
c. Give a fluid bolus and take blood cultures. Discuss with the oncall microbiologist as he is septic to ensure he is on the most appropriate antibiotics.
d. Carry out a full systems examination. Providing they are normal give him a bolus of iv morphine sulphate, and diclofenac pr, prescribe his paracetamol iv and review him in an hour.
e. Take blood cultures and give a bolus of morphine iv. Arrange an USS of his abdomen as he likely has a collection of pus.

3. The patient from question 2 was discharged well after 5 days of antibiotics. He returns 6 months later with a one day history of periumbilical abdominal pain and vomiting. The vomiting was yellow last night but now has a greenish tinge. He opened his bowels yesterday which were loose. Clinically he has dry mucous membranes, his heart rate is 130 and respiratory rate 28 and his peripheries are cool. He has not passed urine for 8 hours. His abdomen is vaguely tender in the periumbilical area and a little full. There are no masses or hernias.

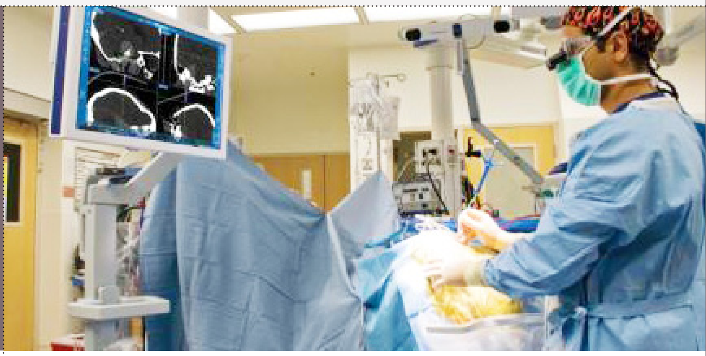
a. Place an IV canula, send bloods for FBC, UE, CRP, Amylase and pass an NG tube. Give a fluid bolus and request an USS.
b. Place an IV canula, send bloods for FBC, UE, CRP, Amylase and pass an NG tube. Give a fluid bolus and request a CT scan.
c. Place an IV canula, send bloods for FBC, UE, CRP, Amylase and pass an NG tube. Give a fluid bolus and request a plain abdominal film.
d. Place an IV canula, send bloods for FBC, UE, CRP, Amylase and pass an NG tube and urinary catheter. Book him for a laparoscopy.
e. Start him on oral rehydration therapy and refer him to the paediatricians for his gastroenteritis as he no longer has an appendix.

4. While you are scrubbed for a laparotomy you are called by the ED registrar, who would like to refer a 5 year old patient for observation. He was hit by a car when he ran out into the road. He has been very distressed and crying and so his heart rate has been around 150 since arrival and his respiratory rate is unrecordable because of the crying. He is saturating normally in air. He has no signs of a head injury, he has some bruises and grazes to his right chest and abdomen and clinically has broken his right radius and ulna which has been splinted by the paramedics. He screams wherever you touch him making examination very difficult. A chest x-ray shows clear lungfields and no boney injury. An x-ray pelvis was normal. A FAST scan showed no free fluid in the abdomen. In view of the mechanism of injury the ED doctor would like him observed overnight on your ward.

MANAGEMENT OF THE SICK SURGICAL CHILD

G Shepherd

Management of the Sick Surgical Child.
Paediatric Surgery.



a. You accept the patient on the provision the patient has good IV access, has had a group and save in the department and he is kept nil by mouth so you can review him once he has settled into the ward and you have finished in theatre.
b. You ask them to keep the child in the ED until you finish in theatre so you can see the patient in the ED and having confirmed the clinical findings accept him to the ward on the provision the patient has good IV access, has had a group and save in the department, he is kept nil by mouth and you will review him again once he has settled into the ward.
c. You ask them to keep the child in the ED until you finish in theatre so you can see the patient in the ED and having confirmed the clinical findings, give the patient more analgesia, some iv fluids, crossmatch him for four units of blood and book him for theatre for an urgent laparotomy as you suspect a visceral injury.
d. You ask the ED doctor to arrange a CT scan based on his findings, to rule out any visceral injury and you will attend once you have finished in theatre.
e. You do not accept the patient as he has no surgical problem.

5. You are called to see the same child from question 4 on the ward. It is now 24 hours since the accident. A CT scan confirmed a normal liver, gallbladder, spleen and kidneys. There was no free fluid or air. The child has developed increasing pain in the abdomen, spiked a temperature of 38 degrees. His heart rate has increased gradually from 100 to 130 and he is very quiet but alert, lying in bed. He is tender thoughout his abdomen. A fluid bolus brings his pulse down to 115 and he seems a little brighter, but he is still tender. A plain abdominal film and erect chest x-ray, requested by the house officer are normal.

a. You give the patient stronger analgesia and review him in an hour.
b. You ask the house officer to take a set of bloods, including an amylase and blood cultures, give another fluid bolus and arrange an USS.
c. Liaise with the paediatricians for a review as he is septic and the normal CT scan rules out any surgical pathology.
d. You ask the house officer to take a set of bloods, including blood cultures, give another fluid bolus and book him for theatre for a laparotomy.
e. You ask the house officer to take a set of bloods, including an amylase and blood culture, give another fluid bolus and once stable arrange a repeat CT scan.

Answers

1. b: ABC comes first. Iv access has failed and so the quickest way to enable fluid resuscitation of this severely dehydrated child is via the intraosseous route. A capillary gas will help to establish a metabolic alkalosis or acidosis with assessment of the bicarbonate and chloride to help guide management. Surgical correction of a pyloric stenosis is not an emergency, but the fluid resuscitation is. If acidotic then a septic screen will also need to be performed. Clinical examination alongside the capillary gas will help guide the likelihood of other surgical pathologies before considering USS or GI contrast studies.

2. d: Although a rising pulse rate and respiratory rate make one suspicious of dehydration, a good urine output means he is unlikely to be underfilled. Pain however can also induce these changes and restrict adequate ventilation. Oral paracetamol and codeine are unlikely to be sufficient analgesia and probably will not be absorbed from the gut very well this soon postop. A review is necessary to ensure a response and ensure no other signs have developed that may point towards another cause.

3. c: A plain film is the most useful investigation to assess obstruction. Proximal bowel obstruction causes less abdominal distension than distal bowel obstruction.

4. d: The patients persistant tachycardia should not be assumed to be due to his crying and pain until proven otherwise. A normal FAST scan does not rule out visceral injury in children. A CT scan is the investigation of choice for blunt abdominal trauma.

5. e: An amylase is a useful test as it is raised in pancreatitis and to a lesser degree in bowel perforation. Bruised bowel is at risk of subsequent perforation, and in the stable patient a CT scan would be the definitive investigation of choice.

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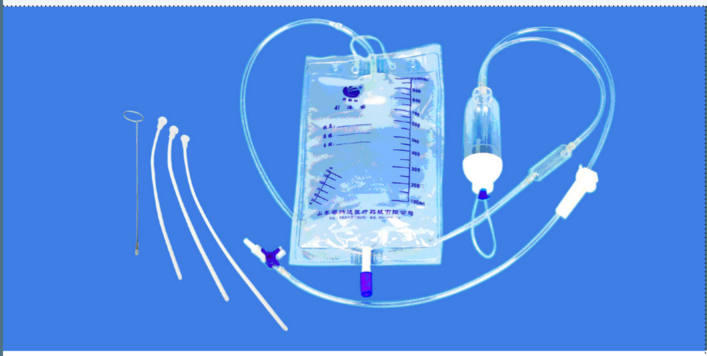
EXTERNAL VENTRICULAR DRAINAGE

MG Hart



External Ventricular Drainage.
Neurosurgery.

Practical Procedure

Insertion of an external ventricular drain (EVD) is one of the most common neurosurgical operations. It is frequently performed in critically ill patients as an emergency procedure during out of hours operating. The Intercollegiate Surgical Curriculum Project (ISCP) states that all neurosurgical trainees must be able to do the procedure under indirect supervision during initial training, and without assistance – including management of complications – during intermediate training. This article aims to provide a précis of surgical technique involved and an amalgamation of current research in the area.

Indications and Contra-indications

The main indication for an EVD is hydrocephalus. Ventriculostomy can be effective as part of an ICP-controlling protocol after traumatic brain injury.(1) Ventricular access also allows administration of intra-thecal chemotherapy or antibiotics. During skull base and vascular surgery ventricular drainage is performed intra-operatively to reduce requirements for brain retraction. The main contra-indication is coagulopathy. Rough guidelines are platelets of >100 and an INR of <1.4.

Consent

Many patients requiring an EVD will be unconscious and unable to consent for themselves. As treatment in this instance can be life-saving the procedure is usually performed under common law for the patient's best interests as judged by the attending medical practitioner. It is best practice to inform the patient's family and next of kin. While there are complications that can arise from EVD insertion, chiefly infection but also haemorrhage, the seriousness of untreated hydrocephalus means that these risks are rarely sufficient to withhold the procedure.

Pre-procedure checks

Prior to proceeding to theatre all patients should have a World Health Organisation (WHO) surgical safety checklist (or equivalent) started which can then be completed during the pre-procedure 'timeout'. A recent computed tomogram (CT) scan should be available in theatre during the procedure. Important details to discern from this scan include: ventricular size (particularly if the ventricles are slit-like); ventricle position (e.g. if they are distorted due to a craniectomy); adhesions (commonly found in pyogenic ventriculitis); and the presence of intra-ventricular haemorrhage. The surgical equipment required is detailed in table 1.

Horseshoe ring
Hair clippers
Scalpel and number 10 blade
Bipolar cautery
Suction
Adjustable self-retaining retractor
Pericranial elevator or Adson
Perforator (14mm) or high speed drill
Dandy cannula or stylet
Intra-ventricular catheter
Tunnelling device
Collection pot for CSF sampling
External drainage bag e.g. Becker
Sutures: 2.0 silk for drain, 3.0 vicryl for galea, 3.0 vicryl rapide or clips for skin
Sterile dressing

Table 1: Equipment required for EVD insertion

Preparation: equipment, draping and positioning

The ventricles can be drained by a variety of means. An EVD usually refers to a catheter inserted into the ventricle and connected directly to an external drainage bag. Alternatively a silicone reservoir dome may be connected to the ventricular catheter and secured in the sub-galeal space. This is known as an Ommaya or Rickham reservoir or Ventricular Access Device (figure 1). These do not need to be removed routinely and can provide ventricular drainage percutaneously via a 22G butterly needle attached to an external drainage bag. Image guidance can be used with slit ventricles or distorted anatomy.

A: EVD

B: VAD

Figure 1

EXTERNAL VENTRICULAR DRAINAGE

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For freehand insertion the patient is positioned supine in a horseshoe with the head up at between 30-45 degrees. If image guidance is to be used the patient should have their head immobilised in a Mayfield 3-pin fixator. Various strategies exist for locating the ideal entry location for the incision and burr hole. Usually the frontal horn of the lateral ventricle adjacent to the foramen of Munro is the preferred location for the distal end of the catheter although other locations can be selected.

The main anatomical structures to avoid during EVD insertion include the superior sagital sinus, the dominant hemisphere and the motor strip. One well described landmark for cannulating the frontal horn is Kocher's point which lies in the mid-pupillary line 1cm anterior to the coronal suture. The coronal suture can be palpated or calculated according to Taylor-Haughton lines (figure 2). Measurements in specimens have determined this point is approximately 10-12cm posterior to the nasion.(2) The right side is preferred as even in left handed people (approximately 8-15% of the population) only 25% will be right hemisphere dominant.(3)

- **Nasion**
- **Inter-hemispheric line/superior sagital sinus**
- **Mid-pupillary line/3cm from midline**
- **Kocher's point**
- **Coronal suture**
- **Mid-point of nasion-inion line**
- **Superior aspect of motor strip**
- **Sagital suture**
- **Inion**

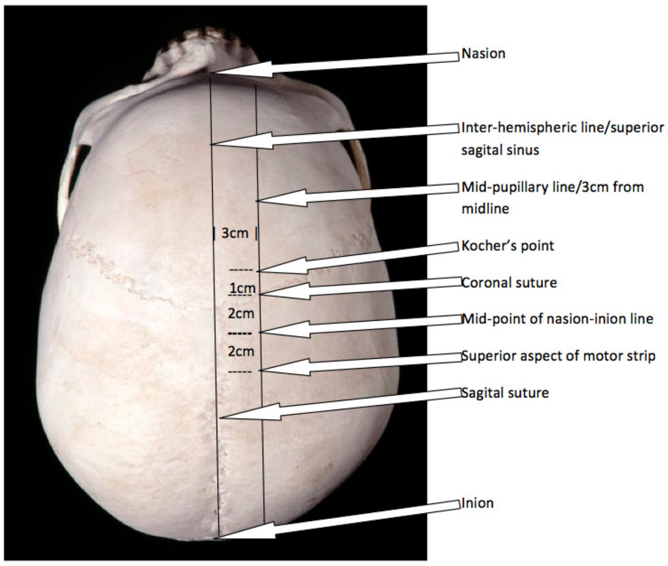

Figure 2: Taylor-Haughton lines and Kocher's point

Once the position has been marked, a half-head shave is performed to allow positioning of a strain relief loop without entanglement in hair. Clippers are preferred to a razor due to a lower infection rate (4). The skin should be prepped with chlorhexidine, which has been shown to be more effective than iodine,(5) whilst the surgeon scrubs to allow an adequate exposure time for the solution to work. Surgeons should double glove prior to draping. The orientation of sterile drapes should allow easy palpation of key cranio-facial landmarks (nasion, ipsilateral medial canthus, external auditory meatus and tragus) with Ioban covering as the final layer. Sub-cuticular local anaesthetic with adrenalin can be administered to aid haemostasis and, when inserted to the sub-galeal space, to dilate a tract for tunnelling of the distal tubing. Intra-venous antibiotics are administered prior to procedure commencement in line with local policy. Systematic reviews of the literature have found no clear evidence that antibiotics reduce infections in CSF shunt surgery.(6)

Procedure

A 30mm linear incision is performed with a number 10 blade. A semi-lunar incision and sub-galeal flap may be fashioned if implantation of a VAD is expected. The concave aspect can be orientated anteriorly to increase vascular supply to the pedicle or to the occiput to increase hypoaesthesia over the skin if frequent accessing is expected. Haemostasis is ensured with bipolar cautery. A 14mm burr hole is made with a perforator or high speed drill. A minimal durotomy is performed to prevent CSF exenteration. The tip of the Dandy cannula can be used to perform this. Bipolar cautery is used to perform a limited pia-arachnoid corticotomy.

The cannula is inserted with the aid of the rigid Dandy stylet. Normally the frontal horn of the lateral ventricle adjacent to the foramen of Munro is the preferred location due to possible lower rates of catheter blockage by choroid plexus although other locations are possible. The vector for this is usually posteriorly towards the tragus, medially towards the nasion, and inferiorly; a trajectory perpendicular to the skull is usually ideal. If the burr hole is too far posteriorly the trajectory will not intersect the frontal horn which is the widest part of the lateral ventricle. A trajectory too lateral will commonly enter into the ipsilateral caudate nucleus.

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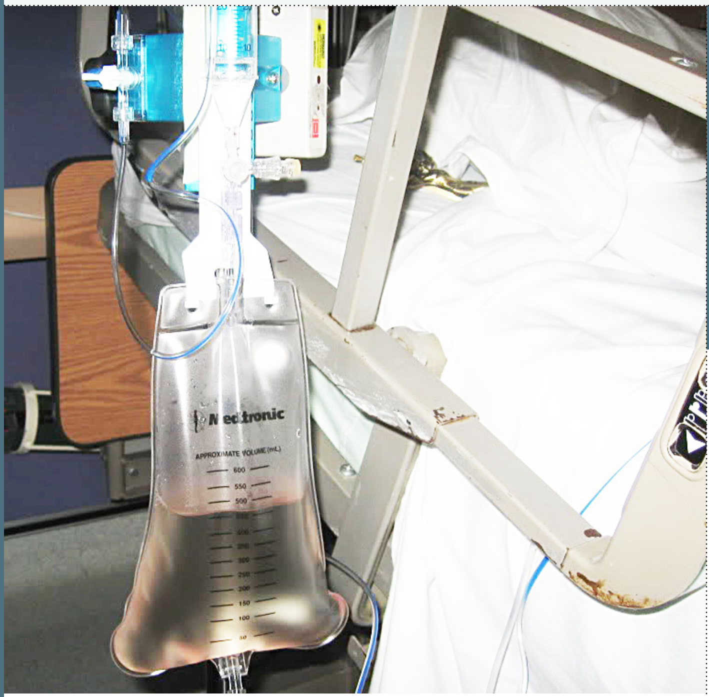

External Ventricular Drainage.
Neurosurgery.

It is imperative not to insert the cannula deeper than 60 mm. Insertion deeper than this is usually due to an incorrect trajectory and will lead to mal-positioning. In the presence of ventriculomegaly CSF should be encountered by 30-40mm. In the situation where CSF is not easily flowing saline may be irrigated gently and seen to be oscillating if there is a solid column of fluid.

After insertion of the cannula CSF pressure and appearance should be documented, particularly if it is haemorrhagic or turbid. Routine samples should be sent routinely to microbiology for cell count, gram stain and culture and a separate sample to biochemistry for protein and glucose.

Prior to skin closure the distal tubing is tunnelled 8cm away from the incision in the sub-galeal space. The incision is closed in layers with 3.0 vicryl to the galea and clips or vicryl rapide to the skin. Finally a strain relief loop is fashioned with the distal tubing and a sterile dressing applied. A head bandage is optional but can be useful in children to prevent tampering with the tubing.

Post-operative Care

The distal end of the EVD is connected to a Becker EVD kit to control drainage pressure and monitor drainage volume (figure 3). Over-drainage beyond the rate of normal CSF formation can result in pneumocephalus. Cautious drainage is advised in sub-arachnoid haemorrhage with an un-secured aneurysm as a rapid reduction in trans-mural pressure can result in re-rupture. Under-drainage will lead to a delay in symptom resolution and possible CSF leak from the wound. All patients should be on routine neuro-observations post-operatively according to protocol. Oscillation and drainage of CSF must be documented hourly. If the Glasgow Coma Scale (GCS) or symptoms do not rapidly improve this may indicate incorrect catheter placement and warrants urgent CT head scanning.

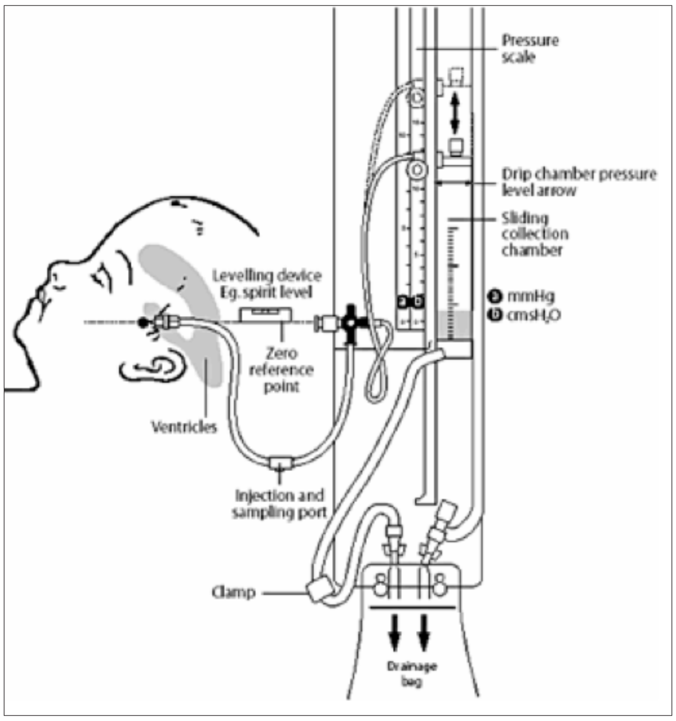

Figure 3: Becker ventricular drainage system

Complications

Mal-positioning of the catheter can occur either at insertion or from catheter migration. New focal deficits such as limb weakness or ocular muscle paralysis may indicate placement in the motor strip or ambient cistern respectively. A retrospective audit found that 40% of EVDs were in the ipsilateral frontal horn, 20% in the third ventricle, 20% in the body of the lateral ventricle, 10% in the sub-arachnoid cisterns, 10% in the brain parenchyma and 3% in the contra-lateral lateral ventricle.(7) Of those that were miss-placed 40% had to be re-positioned compared to a replacement rate of 25% for those which were well positioned. Small ventricles and longer intra-cranial catheter segments were associated with poorer positioning but years of training were not. A virtual reality computer simulation of EVD insertion found that frontal horn EVD cannulation was on average 17mm from the foramen of Munro and 27% of catheters required multiple passes.(8)

EXTERNAL VENTRICULAR DRAINAGE

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Blockage of the ventriculostomy can occur from a variety of reasons including choroid plexus occlusion of the proximal drainage ports, catheter mal-position or migration, and haemorrhage or debris in the tubing. This is usually manifest by the CSF in the Becker EVD kit not oscillating according to pressure, reflecting a column of fluid not in continuity with the ventricles. Untreated, this will result in either a CSF leak through the wound or clinical symptoms of hydrocephalus. If this cannot be relieved by simple flushing of the catheter at the bedside, a CT scan is required to document catheter position, and EVD replacement might be necessary depending on radiological and clinical findings.

Nosocomial infection related to ventriculostomy can lead to considerable morbidity. Data on the epidemiology of such infections is limited by the retrospective nature of many studies and variable diagnostic criteria for ventriculitis. A recent prospective study found the infection rate to be 6.3 per 1,000 drainage days.(9) Risk factors included head injury and IVH. The most common organisms included coagulase negative staphylococcus and staphylococcus aureus.

The detailed management of ventriculostomy associated infections is beyond the scope of this article is based on a combination of clinical and microbiological features.(10) Treatment may include intra-venous or intra-thecal antibiotics with or without EVD replacement.

Current Research

A number of modifications have been proposed to improve catheter insertion accuracy. A series of percutaneously placed catheters found they had improved operating times and fewer passes than freehand placement.(11) Robot guided catheter insertion has been shown to be highly accurate and consistent.(12) The Ghajar guide is a mechanical device that sits on the calvaria and provides an orientation that is precisely tangential to the skull surface.(13) Although these studies report excellent results in selected case series all new technology should be the subject of randomised controlled trials prior to it becoming standard practice.

Improving the infection rate has been the subject of considerable research. Antibiotic impregnated shunt tubing (Bactiseal) has been proposed to lower infection rates and a retrospective review found that bactiseal shunts had a lower infection rate than conventional shunts(14) there is no prospective evidence and no evidence on EVD related infections.

Silver impregnated catheters have also been suggested to improve infection rates. A retrospective study found silver impregnated catheters had a lower infection rate than standard catheters.(15) A recently completed RCT found that silver impregnated catheters (Silverline®) had a lower infection rate than standard catheters.(16) A multi-centre RCT of Silverline® versus Bactiseal® versus standard catheters for ventricul-peritoneal shunts (BASIC trial) is about to start in the UK and will hopefully provide the definitive answer regarding which shunt tubing is best.

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EXTERNAL VENTRICULAR DRAINAGE

MG Hart

Questions

1. Which of the following is not an indication for an External Ventricular Drain (EVD):

a. Control of ICP in after head injury
b. Reduction in the amount of retraction required in skull base surgery
c. Management of Normal Pressure Hydrocephalus (NPH)
d. Emergency drainage of acute hydrocephalus
e. Stabilisation of patients with early poor grade sub-arachnoid haemorrhage & enlarged ventricles

2. Regarding infection, which statement is most correct:

a. The risk of infection increases with the number of days a drain is left in-situ;
b. The most common organisms are related to secondary colonisation from a bacteraemia associated with systemic infection;
c. Ventriculitis is rarely associated with a rise in inflammatory markers or pyrexia;
d. A confirmed organism infection with an EVD in-situ mandates changing of the EVD in theatre:
e. A successfully treated CSF infection is not a risk factor for morbidity, long-term cognitive function or requirement for a shunt.

3. The following investigations are useful in the assessment of the blocked EVD except:

a. Inspection of the Becker External Drainage set;
b. Flushing of the proximal and distal ends of the drain tubing;
c. Inspection of the strain relief loop (if placed) under the dressing to ensure the catheter is not inadvertently kinked by sutures;
d. A CT scan to confirm the EVD position within the ventricle;
e. Changing the Becker External Drainage Set.

4. The following statements regarding EVD placement are correct except:

a. Approximately 40% of EVDs are inserted in the correct position;
b. The most common position for a malpositioned shunt is the 3rd ventricle or body of the lateral ventricle;
c. Neurosurgery trainees that have been training are more accurate at EVD insertion;
d. Robotic assisted EVD placement is more accurate than freehand guided;
e. Neuronavigation is indicated in slit ventricles or dysmorphic ventricles.

5. Which of the following statements regarding Evidence Based Medicine is correct:

a. The use of Bactiseal® antibiotic-impregnated shunt tubing is based upon evidence from randomised controlled trials;
b. The use of silver impregnated catheters (Silverline®) for an EVD reduces the infection rate from 21% to 12%;
c. Frontal approach catheter insertion has a lower risk of infection than the parietal approach;
d. Silver impregnated shunt tubing (Silverline®) has the lowest infection rate when used for a ventriculo-peritoneal shunt;
e. A strict 'non-handling' protocol for the post-op management of EVDs is based on level 1 evidence.

Answers

1. C.

Typically the hydrocephalus in this condition is of low pressure and does not require emergency drainage. Workup usually includes a combination of lumbar drainage and/or infusion studies followed by a ventriculo-peritoneal shunt in suitable candidates.

2. A.

Most organisms are commensal organisms from the skin: secondary colonisation of an EVD does occur but is less common. Ventriculitis can by cryptic (without a systemic response) but often there is significant systemic upset. While changing an EVD when CSF infection is detected may seem to make sense, there is a risk with every additional procedure and practice varies between surgeons. Therefore each case must be considered on an individual basis. A CSF infection, particularly in children, has been shown in numerous studies to be a risk for a poorer long-term outcome.

3. E.

All of the others should be part of a 'protocol' for inspection when asked to review a possibly blocked EVD. Changing the Becker External Drainage set by itself is unnecessary once the tubing has been flushed thoroughly, is expensive, and offers the potential for introducing infection.

4. C.

All the rest are true, although practice will vary between units and surgeons.

5. B.

A recent RCT has confirmed that Silverline®is successful in reducing the infection rate of EVDs but not VPS: Bactiseal® catheter use has not been the subject of an RCT. Although a 'non-handling' protocol may seem to make sense for reducing infection rate, and there are numerous audits confirming its effectiveness, there are no RCTs on the subject. The frontal approach may reduce obstructive complications but is not believed to reduce infection rates.

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AN ACADEMIC CAREER IN TRAUMA AND ORTHOPAEDICS EXPLAINED

N A Smith

An academic career in trauma and orthopaedics explained.
Career Focus.

Until recently, there has been no clear structure for someone wanting to pursue a career in academia as well as trauma and orthopaedics. Each senior academic of today has had to make their own path, often with periods no pay and prejudice about lack of clinical skills. Most junior doctors wishing to apply for a training post will be painfully aware of the need for publications to even be shortlisted, often with little guidance on research techniques. This desperate search for a quick publication is the furthest many trainees enter the world of academia. However, for those wishing to pursue an academic career within the specialty, it is now much easier.

Walport report

In 2005 the Walport report, a joint venture of modernising medical careers (MMC) and the UK clinical research collaboration, set about identifying and addressing the obstacles to people wishing to pursue both an academic and clinical career within their chosen specialty.[1] They found that there wasn't a clear structure for aspiring academics, there was a lack of flexibility in training and there were very few senior posts on completion of academic training. All of these issues have been addressed, based on the recommendations of this report.

Entry points into academia

In response, there are now clearly defined entry points into research. (fig.1) The first is as a foundation doctor. Within an academic foundation programme, one four month slot is dedicated to research, with the aim of exploring an interest in a research topic. This gives you an excellent opportunity to develop some projects, maybe get a publication or two, and most importantly give you a taste of clinical research.

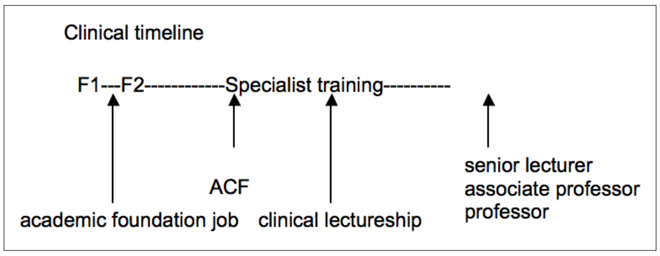


Figure 1. The arrows denote competitive entry points.

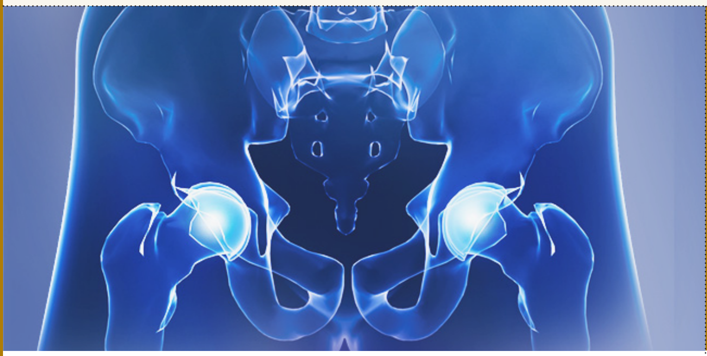
The second clearly defined entry point is at specialist training year 1 (ST1) level, where you can apply for an academic clinical fellowship (ACF). The ACF post is integrated with a run through clinical training post (ST1-8) and you are awarded both on successful application. The ACF is funded for 3 years within your clinical training, in which 25% of your time is protected for research. You can take this as a block period within your training, and it is generally used to put together a grant application for a PhD project. If you were successful in your application for funding, you would then need to take 2 or 3 years out of training to complete your PhD. Your salary would come from the funding body, usually at NHS basic rate for your year of training.

On successful completion of a higher degree, usually a PhD, the third clearly defined entry point is a clinical lectureship post. Whilst you do not need to have been an ACF, you do need a strong track record of academic achievement including a higher degree. This post is designed to follow on from an ACF and takes you to the end of your registrar training. As a clinical lecturer, you have the opportunity to continue your postdoctoral research, such as multi-centre trials. You are also expected to develop your teaching and would be expected to be a supervisor to PhD students. On completion of a clinical lectureship, you will have completed your clinical training and then may apply for consultant jobs.

A job as an academic consultant would take the form of an associate professor (senior lecturer). These jobs vary depending on the department, but broadly represent further development of the clinical lectureship. You would have increasing roles in teaching, bringing in external funding and leading large trials. Again, it is not essential that you have been through the new academic route, but it is essential that you have a strong academic background and a higher degree would be essential. If you had been through the academic route from the beginning, you would be well placed for an associate professor job. The time spent doing academic work is often dependent on the department but may represent 30 -50% of your workload.

AN ACADEMIC CAREER IN TRAUMA AND ORTHOPAEDICS EXPLAINED

N A Smith



An academic career in trauma and orthopaedics explained.
Career Focus.

Flexibility

If a trainee takes an academic post, they are not then committed to a lifetime of clinical research. If, for example an ACF trainee did not wish to pursue a further academic career on completion of their ACF, they are under no obligation to take a clinical lectureship post. They would simply enter the clinical training pathway, without the need to apply again. Similarly, if you are already a foundation doctor, but not in an academic post, this does not exclude you from applying for an ACF, and someone that had pursued a higher degree outside of the ACF may apply for a clinical lectureship post.

Advantages of an academic career

Many people choose an academic career because it gives variety in your work as well as giving intellectual stimulation. Being able to appraise the literature critically in an age of evidence based medicine is also a powerful tool and it allows you to improve your clinical decision making. Following an academic pathway also allows you to meet many senior surgeons and academics, giving you the chance to make contacts and open doors for your future, both in research collaboration and potentially future job prospects. Trauma and orthopaedics traditionally doesn't have a strong reputation for research. This is slowly changing, and if you want to be a part of this and be at the top of the specialty in the future, an academic career may be for you. It also doesn't do the research part of your CV any harm!

The creation of an ACF post has made successful application and completion of a PhD much easier for a number of reasons. A department that has been awarded ACF posts must have shown to have a good set up and support structure for ACFs to successfully apply for and complete a higher degree. This means you will have access to senior academics for guidance, statisticians and often other ACFs that have already had their projects funded. In my programme, we have weekly teaching on research methods and a funded master's degree in trauma and orthopaedic surgery. On top of this, having the flexibility of 25% of your time allocated to research allows you to make a very competitive application for a grant, something that is very difficult to do within a full time training post.

Disadvantages

Simultaneously pursuing an academic and a surgical career means longer hours and often later nights. With the European working time directive (EWTD) reducing clinical hours to a bare minimum, you must not let your clinical and cutting time be wasted. As an ACF, you may have up to 25% less time in theatre and clinics than a clinical trainee. As a clinical lecturer, up to 50% of your time may be dedicated to research. In order to juggle the two, you need to be organised, and make the most of every clinical opportunity. In my experience, both clinical and academic supervisors have been very supportive and you often have more freedom to choose the direction of your training.

Advice

ACF posts in trauma and orthopaedics are highly competitive, and they are in short supply. If you are considering applying for an academic post, my advice would be to start some research projects as soon as possible. It is often best to go to your local department, particularly if they have an academic set up, as there are often projects that you can get involved in. The shortlisters for ACF posts are looking for people with an academic interest and potential, so you don't need to have published 20 articles in the Lancet, but you do need to show that you are committed. The ACF posts generally come out towards the end of the year, before the main ST1 clinical posts, so if you are unsuccessful you can still apply for a clinical training post.

References

1. Modernising Medical Careers and the UK Clinical Research Collaboration. Medically- and dentally-qualified academic staff: Recommendations for training the researchers and educators of the future. **www.ukcrc.org/index.aspx?o=3146 (accessed 07 July 2011)**

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HELPING VICTIMS OF THE HAITIAN EARTHQUAKE

DTS Chou

Helping victims of the Haitian Earthquake.
Charitable Experience.

The Humanity First Medical Disaster Response Team sent a team of six doctors and three paramedics to treat victims of the Haitian Earthquake. I was a CT2 orthopaedic trainee at the time and one of the doctors on the team. We carried with us all the necessary equipment to be self sufficient for two weeks and to provide medical assistance to the victims.

Tents, sleeping bags, energy bars, plaster of paris, local anaesthetics and all manner of drugs, not to mention an electricity generator, solar panels and a satellite phone. Landing at Punta Cana, an airport synonymous with honeymoons and beach holidays was not only very surreal but also vividly demonstrative of the contrasting priorities of humans in different circumstances.

We set up a mobile medical camp near the town of Carrefour, only a few kilometres from the epicentre of the earthquake. Security in that environment was crucial and was provided by the UN troops on the ground. From 9am to 5pm our clinic was running non-stop. Every morning we arrived to a queue of people waiting to see us.

Each day we saw on average of about 500 patients. All types of patients were treated. Initially many had earthquake related injuries such as untreated fractures and soft tissue injuries but gradually towards the end of our stay patients presented with other health conditions such as hypertension, diabetes, malaria as well as psychological troubles.

Being the orthopaedic doctor on the team I saw all of the potential fractures, joint problems and wound issues. Despite minimal equipment the diagnosis of a fracture was relatively straightforward. People had turned wooden poles into crutches and wheelbarrows into wheelchairs. One young girl I saw with a midshaft humerus fracture had been treated with a couple of wooden planks wrapped around her arm and a piece of cloth as a sling.

Following the earthquake many people had suffered large wounds from falling debris. With no facilities to close the wounds primarily, many patients presented two weeks later with large infected wounds that required debridement. We performed these procedures using ketamine anaesthesia, regional or local blocks. Many such patients required IV antibiotics to prevent ongoing sepsis. Setting up the medical camp in the same area allowed us to review the wounds at 48 hours and monitor progress.

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Without the availability of x-rays, orthopaedic classification systems and the questions so often put to junior trainees in trauma meetings became completely obsolete. The challenge in Haiti was to formulate a management plan that was safe and appropriate for the expectations of the local population and the medical infrastructure in place following the earthquake.

Field hospitals with theatres for basic surgical procedures were available as well as some hospitals with facilities for more demanding procedures. Even in those patients who required operative fixation one had to ask whether the patient and the medical infrastructure would be able to cope with post-operative care and potential complications.

When we initially drove into Port-au-Prince I remember thinking how TV images of the disaster could never do justice to the shear scale of destruction and chaos caused by the earthquake. Crushed buildings still hadn't been cleared and it was clear from the stench in the air that rotting bodies were lying underneath. Whilst seeing patients in clinic and listening to their individual stories about lost family members, scarcity of food, money and shelter I started to understand the reality of human suffering.

Two weeks after the earthquake people were still walking around with untreated fractures and people becoming septic from large infected wounds. As a team of medics we were able to treat hundreds of patients who would have otherwise remained untreated, become very sick and potentially have died. Although our efforts may have changed the lives of a few hundred people at the time I couldn't help thinking at the time that the country was truly crippled and without further aid and support thousands would continue to suffer.

After the departure of the Disaster Response team, Humanity First continued to provide aid and support to the earthquake victims through continued healthcare services as well as shelter, food, sanitation, education and orphan care services. Humanity First is an international aid agency that provides aid and assistance to those in need irrespective of race, religion, or politics from registered offices in 33 different countries. For more information see the website at www.humanityfirst.org.

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