Ellis and Calne's Lecture Notes in GENERAL SURGERY

Christopher Watson
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14th Edition

with website

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Ellis and Calne's
Lecture Notes in General Surgery

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Preface

Many medical students will have effectively written their own textbook at the end of their clinical course – a digest of the lectures and tutorials assiduously attended and of the textbooks meticulously read. Unfortunately, students may approach the qualifying examinations burdened by the thought of many pages of excellent and exhaustive textbooks wherein lies the wisdom required of them by the examiners. Although the Internet is increasingly used as a source of information, we believe that there is still a serious need for a book that briefly sets out the important facts in General Surgery that are classified, analysed and, as far as possible, rationalized for the revision student. These lecture notes represent such a text; they are in no way a substitute for the standard textbooks, but they do draw together, in a logical way, the fundamentals of General Surgery and its subspecialties. As such we hope it will also be of use to the junior surgeon.

We wish to point the reader to the electronic resource accompanying the text, including case studies, radiographs and histology slides illustrating common conditions mentioned in the text, as well as a quiz to test the reader's knowledge.

The first edition of *Lecture Notes in General Surgery* was written by Harold Ellis and Sir Roy Calne and published in 1965. This is the first edition without their involvement, and we acknowledge their huge contribution to surgery and its teaching. Surgery has changed enormously since the days of that first edition, and each subsequent edition has tried to keep pace with surgical practice. Never has the pace of change been so great as it is today. The biggest changes have been seen in the development of specialist services, at the expense of the generalist, and the development of multidisciplinary teams to optimize management. Recognizing this, previous editions have relied heavily on colleagues from other specialties to keep chapters updated and relevant. For this edition we have taken this further, and each chapter now has a nominated expert author – who, for some chapters, has updated previous content; and, for others, has written completely new content – to ensure relevance for today's student.

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We are grateful to our colleagues – senior and junior doctors, and students – who have read and critiqued this text during its production, and to many readers and reviewers for their constructive criticisms. We are indebted to those colleagues in years gone by, too numerous to mention here, who have developed the text upon which the new chapter experts have built. We would also like to acknowledge the continued help give by the staff at Wiley for seeing this project through to publication, in particular James Watson, Catriona King, Mandy Collison, Ella Elliott, and Indirakumari Siva.

Abbreviations

ABPI	ankle brachial pressure index
ABG	arterial blood gas
ABLS	Advanced Burns Life Support
ACE	angiotensin-converting enzyme
ACTH	adrenocorticotrophic hormone
ADH	antidiuretic hormone
ADT	androgen deprivation therapy
AFP	α-fetoprotein
AIs	aromatase inhibitors
AIDS	acquired immune deficiency syndrome
AIN	anal intraepithelial neoplasia
AJCC	American Joint Committee on Cancer
ALK	anaplastic lymphoma kinase
ALP	alkaline phosphatase
ALT	alanine transaminase
ANC	axillary node clearance
ANS	axillary node sampling
ANUG	acute necrotizing ulcerative gingivitis
APFC	acute peripancreatic fluid collection
APACHE	Acute Physiology and Chronic Health Evaluation
APTT	activated partial thromboplastin time
APUD	amine precursor uptake and decarboxylation
ASA	American Society of Anesthesiologists
ASD	atrial septal defect
ASIA	American Spinal Injury Association
AST	aspartate transaminase
ATN	acute tubular necrosis
ATLS	Advanced Trauma Life Support
AXR	abdominal X-ray
β-HCG	β-human chorionic gonadotrophin
BCG	bacille Calmette–Guérin
BCS	breast conserving surgery
BMI	body mass index
BPH	benign prostatic hyperplasia
CABG	coronary artery bypass graft
CAPOX	capecitabine and oxaliplatin
CAR	chimeric antigen receptor
CaSR	calcium sensing receptor
CEA	carcinoembryonic antigen
CEAP	Clinical, Etiological, Anatomical and Pathophysiological
CHRPE	congenital hypertrophy of the retinal pigment epithelium
CMV	cytomegalovirus
CNS	central nervous system
COPD	chronic obstructive pulmonary disease
CPAP	continuous positive airways pressure
CPE	carbapenemase-producing enterobacteriaceae
CPPS	chronic pelvic pain syndrome
CRE	carbopenem-resistant enterobacteriaceae
CRP	C-reactive protein
CSF	cerebrospinal fluid
CT	computed tomography
CTLA4	cytotoxic lymphocyte–associated antigen 4
CTPA	computed tomographic pulmonary angiography
CVP	central venous pressure
CXR	chest X-ray
DBD	donation after brain-stem death
DCD	donation after circulatory death
DCIS	ductal carcinoma *in situ*
DCS	damage control surgery
DDAVP	deamino-D-arginine vasopressin
DHCA	deep hypothermic circulatory arrest
DIC	disseminated intravascular coagultion
DIOS	distal intestinal obstruction syndrome
DMSA	dimercaptosuccinic acid
DOPA	dihydroxyphenyl alanine
DST	dexamethasone suppression test
DTC	differentiated thyroid cancer
DTPA	diethylene triamine penta-acetic acid

DVT	deep venous thrombosis
EBV	Epstein-Barr virus
ECG	electrocardiogram
ECST	European Carotid Surgery Trial
EGFR	epidermal growth factor receptor
EGC	early gastric cancer
EMG	electromyography
EMR	endoscopic mucosal resection
EMSB	Emergency Management of Severe Burns
ER	oestrogen receptor
ERAS	Enhanced Recovery After Surgery
ERCP	endoscopic retrograde cholangiopancreatography
ESBL	extended spectrum β-lactamase
ESD	endoscopic submucosal dissection
ESR	erythrocyte sedimentation rate
ESWL	extracorporeal shock-wave lithotripsy
EUS	endoscopic or endoluminal ultrasound
EVAR	Endovascular Aneurysm Repair
5-FU	5-fluorouracil
FAP	familial adenomatous polyposis
FAST	focused abdominal sonography for trauma
FBC	full blood count
FDG	fluorodeoxyglucose
FEV_1	forced expiratory volume in 1 second
FFP	fresh frozen plasma
FIT	faecal immunochemical test
FNAC	fine-needle aspiration cytology
FOLFOX	folinic acid and oxaliplatin
FSH	follicle-stimulating hormone
GABA	γ-aminobutyric acid
GANT	gastrointestinal autonomic nervous tumour
GCS	Glasgow Coma Score
GEP-NETs	gastroenteropancreatic neuroendocrine tumours
GFR	glomerular filtration rate
GGT	γ-glutamyl transferase
GI	gastrointestinal
GIM	gastrointestinal metaplasia
GIST	gastrointestinal stromal tumour
GLA	γ-linolenic acid
GOJ	gastro-oesophageal junction
GnRH	gonadotrophin-releasing hormone
GORD	gastroesophageal reflux disease
GPA	granulomatosis with polyangiitis
GTN	glyceryl trinitrate
HAART	highly active antiretroviral treatment
HALO	haemorrhoidal artery ligation
HALT	hungry, anxious/angry, late, tired
HAMN	high-grade appendiceal mucinous neoplasms
HbA1c	glycosylated haemoglobin
HCl	hydrochloric acid
HCC	hepatocellular carcinoma
HER2	human epidermal growth factor receptor 2
HGD	high-grade dysplasia
HHT	hereditary haemorrhagic telangiectasia
HHV	human herpes virus
HIPEC	heated intraperitoneal chemotherapy
HIV	human immunodeficiency virus
HLA	human leucocyte antigen
HNPCC	hereditary non-polyposis colon cancer
HoLEP	holmium laser prostatectomy
HPOA	hypertrophic pulmonary osteoarthropathy
HPV	human papilloma virus
HQIP	Healthcare Quality Improvement Partnership
HRT	hormone replacement therapy
HSV	herpes simplex virus
HTIG	human tetanus immunoglobulin
IBD-U	inflammatory bowel disease unclassified
ICC	interstitial cell of Cajal
ICP	intracranial pressure
ICSI	intracytoplasmic sperm injection
ICU	intensive care unit
IFN	interferon
IMA	inferior mesenteric artery
IMV	inferior mesenteric vein
INR	International normalized ratio
IPMN	intraductal papillary mucinous neoplasm
IPSS	International prostate symptom score
ITU	intensive therapy unit
IVC	inferior vena cava
IVF	*in vitro* fertilization

IVU	intravenous urogram
JVP	jugular venous pressure
KSHV	Kaposi sarcoma herpes virus
KUB	kidneys, ureters and bladder
LAD	left anterior descending artery
LAMN	low-grade appendiceal mucinous neoplasms
LCIS	lobular carcinoma *in situ*
LDH	lactate dehydrogenase
LGD	low-grade dysplasia
LHRH	luteinizing hormone-releasing hormone
LIF	left iliac fossa
LiDCO	transpulmonary lithium dilution cardiac output
LMWH	low-molecular-weight heparin
LUTS	lower urinary tract symptoms
MAG3	*m*ercapto-*a*cetyl tri*g*lycine
MAMC	midarm muscle circumference
MCN	mucinous cystic neoplasm
MDT	multidisciplinary team
MELD	model for end-stage liver disease
MEN	multiple endocrine neoplasia
MHC	major histocompatibility complex
MIBG	meta-iodobenzylguanidine
MIBI	methoxyisobutylisonitrile
MOI	mechanism of injury
mpMRI	multiparametric MRI
MR	magnetic resonance
MRC	Medical Research Council
MRCP	magnetic resonance cholangiopancreatography
MRI	magnetic resonance imaging
MRSA	methicillin-resistant *Staphylococcus aureus*
mTOR	mechanistic target of rapamycin
MUST	Malnutrition Universal Screening Tool (ch 3)
NAFLD	non-alcoholic fatty liver disease
NASCET	North American Symptomatic Carotid Endarterectomy Trial
NCEPOD	National Confidential Enquiry into Perioperative Death
NELA	National Emergency Laparotomy Audit
NEWS	National Early Warning Score
NEN	neuroendocrine neoplasms
NHS	National Health Service
NICE	National Institute of Health and Care Excellence
NG	nasogastric
NOACs	novel oral anticoagulants
NPI	Nottingham Prognostic Index
NSAIDs	non-steroidal anti-inflammatory drugs
NSCLC	non-small cell lung cancer
NSGCT	non-seminomatous germ cell tumour
NST	no special type
OCP	oral contraceptive pill
OPG	orthopantomogram
OPSI	overwhelming post-splenectomy infection
PAC	plasma aldosterone concentration
PBC	primary biliary cholangitis
PCI	percutaneous coronary intervention
pcr	pathologic complete response
PDE5	phosphodiesterase type 5
PDGFA	platelet-derived growth factor receptor α
PDL	programmed death ligand
PE	pulmonary embolism
PEC	percutaneous endoscopic colostomy
PEG	polyethylene glycol
PEG	percutaneous endoscopic gastrostomy
PET	positron emission tomography
PI_RADS	prostate imaging reporting and data system
PICC	peripherally inserted central catheter
PN	parenteral nutrition
PNET	primitive neuroectodermal tumour
POEM	per oral endoscopic myotomy
POSSUM	Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity
PPE	personal protective equipment (ch 2)
PPGL	Phaeochromocytoma and paraganglioma
PPP	patient, procedure and people
PR	progesterone
PRA	plasma renin activity
PRC	plasma renin concentration
PSA	prostate-specific antigen
PSC	primary sclerosing cholangitis
PT	prothrombin time

PTA	percutaneous transluminal angioplasty
PTC	percutaneous transhepatic cholangiography
PTCA	percutaneous transluminal coronary angioplasty
PTFE	polytetrafluoroethylene
PTH	parathormone
PUJ	pelviureteric junction
PV	portal vein
RIF	right iliac fossa
SAH	subarachnoid haemorrhage
SBP	spontaneous bacterial peritonitis
SCLC	small-cell lung cancer
SDHX	succinate dehydrogenase subunit genes
SDM	shared decision-making
SGA	Subjective Global Assessment
SGOT	serum glutamic oxaloacetic transaminase (synonymous with AST)
SGPT	serum glutamic pyruvic transaminase (synonymous with ALT)
SIADH	syndrome of inappropriate antidiuretic hormone
SLE	systemic lupus erythematosus
SLN	sentinel lymph node
SMA	superior mesenteric artery
SMV	superior mesenteric vein
SORT	Surgical Outcome Risk Tool
SSI	surgical site infection
SV	splenic vein
SVT	superficial vein thrombosis
TAD	targeted axillary dissection
TB	tuberculosis
T3	tri-iodothyronine
T4	tetra-iodothyronine, thyroxine
TACE	transarterial chemoembolization
TAE	tumour embolisation
TAP	transversus abdominus plane
TAVI	transaortic valve implantation
TCC	transitional cell carcinoma
TED	thromboembolism deterrent
TEVAR	thoracic endovascular aortic repair
TIA	transient ischaemic attack
TIPS	transjugular intrahepatic portosystemic shunt
TNF	tumour necrosis factor
TNM	tumour node metastasis
TOE	transoesophageal echocardiography
TPA	tissue plasminogen activator
TPN	total parenteral nutrition
TRAM	transverse rectus abdominis myocutaneous
TRH	thyrotrophin-releasing hormone
TRUS	transrectal ultrasound
TSH	thyroid-stimulating hormone
TUR	transurethral resection
UC	urothelial carcinoma
UC	ulcerative colitis
UFH	unfractionated heparin
UKELD	United Kingdom Model for end-stage liver disease
UW	University of Wisconsin
VAB	vacuum-assisted biopsy
VAC	vacuum-assisted closure
VATS	video-assisted thoracoscopic surgery
VAWCM	vacuum-assisted wound closure device with mesh-mediated fascial traction
VEGF	vascular endothelial growth factor
VEGFR-3	vascular endothelial growth factor receptor 3
VET	venous thromboembolism
VIP	vasoactive intestinal polypeptide
VISA	vancomycin-intermediate *Staphylococcus aureus*
VRE	vancomycin-resistant *Enterococcus*
VRSA	Vancomycin-resistant *Staphylococcus aureus*
WHO	World Health Organisation

About the companion website

This book is accompanied by a companion website.

www.wiley.com/go/Watson/GeneralSurgery14

The website features:

- Interactive multiple choice and short-answer questions
- Case Studies
- Extra images and photographs
- Biographies

1

Surgical strategy

Justin Davies

Learning objectives

- ✓ To understand the principles of taking a clear history, performing an appropriate examination, presenting the findings and formulating a management plan for diagnosis and subsequent investigations and treatment.
- ✓ To understand the common nomenclature used in surgery.

The principles of assessing patients referred to a surgical team has changed little in recent times. These include:

1. *Taking an accurate history*.
2. *Examination of the patient*.
3. *Accurate and contemporaneous documentation* (*written and/or electronic*).
4. *Constructing a differential diagnosis*. Ask the question 'What diagnoses would best explain this clinical picture?'
5. *Special investigations*. Which laboratory and imaging tests are required to confirm or refute the clinical diagnosis?
6. *Management*. Decide on the management of the patient, including provision of adequate analgesia. Remember that this will include reassurance, explanation, and good communication skills.

History and examination

Development of clinical skills is of paramount importance in all aspects of medicine and surgery. In some circumstances, excessive reliance on special investigations and extensive imaging may be unnecessary. It is important to remember that the patient may be apprehensive and will often be in pain, especially when presenting as an emergency. Attending to these issues is an especially important aspect of good clinical care.

The history

The history should be an accurate reflection of what the patient has said. It is important to ask open questions such as 'When were you last well?' and 'What happened next?' rather than closed questions such as 'Do you have chest pain?' If you have a positive finding, it is important to explore this further with more directed questioning, for example, 'When did it start?' 'What makes it better, and what makes it worse?' 'Where did it start and where did it go?' 'Did it come and go, or was it constant?' If the symptom is characterized by bleeding, ask about what sort of blood (e.g. fresh, bright red, dark red), when it started, how much, whether there were clots, whether it was mixed in with food/faeces and whether it was associated with pain. Remember that most patients come to see a general surgeon, particularly in the emergency setting, because of abdominal pain or bleeding (Table 1.1). You will need to find out as much as you can about the presenting symptoms.

Keep in mind that the patient may have little accurate anatomical knowledge. They might say 'my stomach

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Table 1.1 Examples of important facts to determine in patients with pain and rectal bleeding

Pain	Rectal bleeding
Exact site	Estimation of amount (often inaccurate)
Radiation	Timing of bleeding
Length of history	Colour – bright red, dark red, black
Periodicity	Accompanying symptoms – pain, vomiting (haematemesis)
Nature – constant/colicky	Associated features – fainting, shock, etc.
Severity	Blood mixed in stool, lying on surface, on toilet paper, in toilet bowl
Relieving and aggravating factors	
Accompanying features (e.g. jaundice, vomiting, haematuria)	

hurts,' but this may be due to lower chest or periumbilical pain – it is important to ask them to point to the site of the pain. Bear in mind that they may be pointing to a site of referred pain, and a vague description such as 'back pain' will need further exploration and clarification as to where it is in the back – the sacrum or lumbar, thoracic or cervical spine, or possibly the loin or subscapular regions. Exploring pain outside of the abdomen is important, particularly shoulder pain. This may, for example, suggest referred pain from the diaphragm or gallbladder.

It is often useful to consider the viscera in terms of their embryology. Thus, epigastric pain is generally from foregut structures such as the stomach, duodenum, liver, gallbladder, spleen and pancreas; periumbilical pain is midgut pain from the small bowel and ascending colon, including the appendix; suprapubic pain is hindgut pain, originating in the colon, rectum and other structures of the cloaca such as the bladder, uterus and Fallopian tubes (Figure 1.1). Testicular pain may also be periumbilical, reflecting the intra-abdominal origin of these organs before their descent into the scrotum – this is exemplified by the child with testicular torsion who initially complains of pain in the centre of their abdomen.

The examination

Remember the classic quartet in this order:

1 Inspection.
2 Palpation.
3 Percussion.
4 Auscultation.

Careful inspection is always time well spent. Inspect the patient generally, as to how they lie and breathe. Are they tachypnoeic because of a chest infection or in response to a metabolic acidosis? Look at the

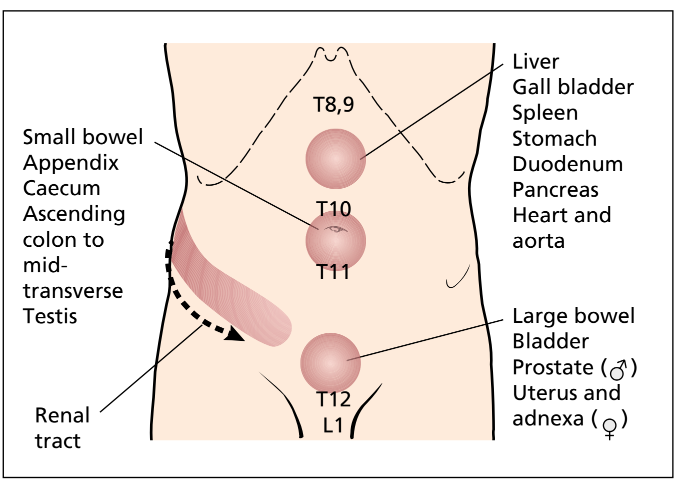

Figure 1.1 Location of referred pain for the abdominal organs.

patient's hands and feel the pulse. Asking the patient to walk may be revealing in someone with claudication or in assessment of general fitness.

Only after careful inspection should palpation start. If you are examining the abdomen in the emergency setting, it is important to ask the patient to cough. This is a surrogate test of rebound tenderness and indicates where the site of inflammation is within the peritoneal cavity. It is often helpful to examine the 'normal' or non-symptomatic side first, be it the abdomen, hand, leg or breast. Look carefully at the patient's face while you palpate, as this may provide subtle clues regarding discomfort or tenderness. If there is a lump, decide which anatomical plane it lies within. Is it in the skin, in the subcutaneous tissue, in the muscle layer or, in the case of the abdomen, in the underlying cavity? Is the lump pulsatile, expansile or mobile?

Documenting medical notes

We practice in an era where electronic patient records are becoming more commonplace, although currently the UK still has the majority of hospitals with paper-based medical records. The number with electronic records will continue to increase over time.

Always write or type your findings completely and accurately in a contemporaneous fashion. Start by recording the date and time of the assessment and check that you have the correct patient's notes open. Record all the negative as well as positive findings. Avoid abbreviations where possible since they may mean different things to different people; for example, PID – you may mean pelvic inflammatory disease, but the next person might interpret it as a prolapsed intervertebral disc. Use the appropriate surgical terminology (Table 1.2).

Table 1.2 Common prefixes and suffixes used in surgery

Prefix	Related organ/structure
angio-	blood vessels
arthro-	a joint
cardio-	heart
cholecysto-	gallbladder
coelio-	peritoneal cavity
colo- and colon-	colon
colpo-	vagina
cysto-	urinary bladder
gastro-	stomach
hepato-	liver
hystero-	uterus
laparo-	peritoneal cavity
mammo- and masto-	breast
nephro-	kidney
oophoro-	ovary
orchid-	testicle
rhino-	nose
thoraco-	chest
Suffix	**Procedure**
-centesis	surgical puncture, often accompanied by drainage, e.g. thoracocentesis
-desis	fusion, e.g. arthrodesis
-ectomy	surgical removal, e.g. colectomy
-oscopy	visual examination, usually through an endoscope, e.g. laparoscopy
-ostomy	creating a new opening (mouth) on the surface, e.g. colostomy
-otomy	surgical incision, e.g. laparotomy
-pexy	surgical fixation, e.g. orchidopexy
-plasty	to mould or reshape, e.g. angioplasty; also to replace with prosthesis, e.g. arthroplasty
-rrhaphy	surgically repair or reinforce, e.g. herniorrhaphy

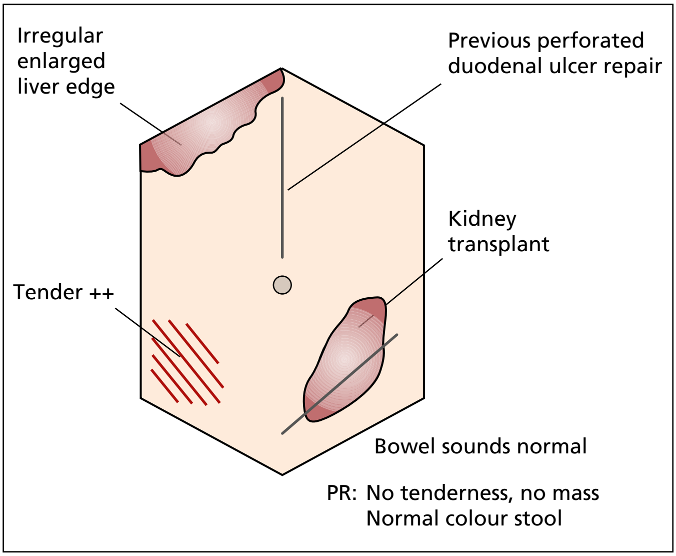

Figure 1.2 Example of how to record abdominal examination findings.

Illustrate your examination unambiguously with simple drawings when possible – use anatomical reference points and measure the diameter of any lumps accurately. When drawing abdominal findings, use a hexagonal representation (Figure 1.2). A continuous line implies an edge; shading can represent an area of tenderness or the site where pain is experienced. If you can feel all around a lump, draw a line to indicate this; if you can feel only the upper margin, show only this. Annotate the drawings with your findings (Figure 1.2). At the end of your notes, write a single paragraph summary and make a diagnosis or record a differential diagnosis. Outline a management plan and state what investigations should be done, indicating those which you have already arranged. Sign your notes and print your name, position and contact details, with the time and date recorded.

Case presentation

The purpose of presenting a case is to convey to your colleagues the salient clinical features, diagnosis or differential diagnosis, management, and investigations of the patient. The presentation should ideally be succinct and to the point, containing important positive and negative findings. At the end of a case presentation, the listening team should have an excellent word picture of the patient and their problems, what needs to be monitored and what plans you have for management.

2

Human factors in surgery

Peter A. Brennan

Learning objectives

- ✓ To understand the factors that can affect safe surgical practice.
- ✓ To know what measures to take to mitigate risks in surgery.

What are human factors?

There are many definitions of this term, but a simple one to remember is how we interact with each other (in teams), the systems in which we work, our variability and the factors that affect our performance and those of team members. In healthcare, human factors application can lead to improved patient safety, better team working and staff morale. Important elements of human factors also include situational awareness, effective team working, safe and effective communication, and good leadership. Furthermore, by recognizing how both physical and mental performance deteriorate over time helps to consolidate their importance.

As humans, we regularly make mistakes, with an average of five to seven simple errors affecting each of us every day. These might be something simple such as forgetting a wallet or a mobile phone when leaving for work because of a distraction. While these errors or omissions might be annoying, error in healthcare is a cause of significant patient harm and mortality. We can never completely eliminate error, and as the above-mentioned examples demonstrate, it is a familiar part of everyday life. The term 'never event' has been coined to describe occurrences that should not occur in a healthcare setting and includes wrong site surgery, retained instruments and swabs, and incorrect naso-gastric tube placement. A 'never event' is somewhat of a misnomer as error can never be completely eliminated, but the chances of error occurring can be minimized.

The Roman Philosopher Cicero (106–43 BC) wrote 'anyone is liable to err (make a mistake), but only a fool persists in error'. Learning from mistakes and sharing lessons widely with others is one of the most important elements to improving patient safety across healthcare.

Error in healthcare

The interplay of human error and human factors in clinical incidents (including factors that have their origins in hospitals where we work) is becoming more widely understood. It is often more than one issue (or layer) that leads to error, and this is readily demonstrated by the well-known Swiss cheese model (Figure 2.1).

Often, factors are multifactorial and take place simultaneously – recognizing this fact is the first step to understanding human factors in surgery. These multifactorial issues include ones that affect us as individuals, such as tiredness, repetition, stress, the effects of distraction and multi-tasking. Other factors can occur as part of team working, and these include poor communication or leadership, loss of situational awareness, and steep (or flat) authority gradients. The introduction of the World Health Organisation

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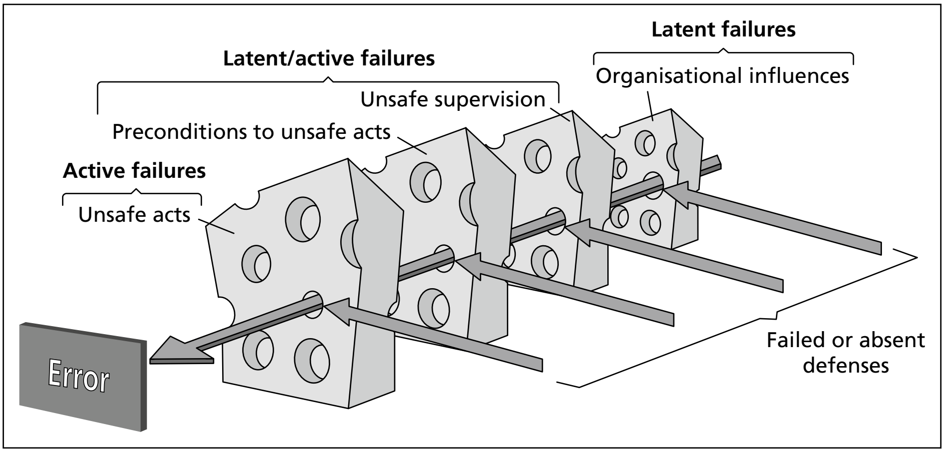

Figure 2.1 The Swiss cheese model of human error. Each slice can act as a barrier.

(WHO) surgical checklist (Figure 2.2) has improved attitudes towards pre-surgery briefing and patient safety, and the benefits of recognizing and applying these human factors principles in surgery are well known.

One in 20 hospital admissions has some form of error, and of these one in 20 are serious (i.e. one in 4,000 admissions). The operating theatre is known to be one of the most potentially error-prone places in the hospital as a result of high patient turnover, site-specific treatments, many heterogeneous surgical procedures, staff limitations and unfamiliar teams.

What are the different types of error and failure?

The Human Factors Analysis and Classification System (HFACS) categorizes failure across four broad domains:

1. Organizational influences.
2. Unsafe supervision.
3. Preconditions to unsafe acts.
4. Unsafe acts.

All four domains can be applied to the Swiss cheese model (Figure 2.1). Failures at each level may be active (decisions, actions or attitudes by individuals or surgical teams) or latent (results of deficiencies with the hospital or management team). Examples of failures in the clinical setting that can have their origin in the employing organization include pressures of overbooked clinics or operating theatre sessions, meeting clinical and hospital targets and prolonged working hours without breaks. Medical error may, therefore, begin to develop well before the actual event itself (such as wrong site surgery) as a result of institutional failure.

What human factors in surgery should we be thinking about?

Table 2.1 summarizes some important human factors that can contribute to and ultimately lead to surgical error, as categorized by the HFACS. These include factors that affect us as individuals, such as tiredness and fatigue; nutritional status; emotional states, including anger and stress; multi-tasking; and loss of situational awareness. These will now be considered further:

Tiredness and fatigue

Commercial aviation recognizes how tiredness and fatigue can influence personal performance and increase the likelihood of accidents, and as a result, rules are in place for maximum work hours. Tiredness (a state that can only be reversed by sleep) and fatigue (more complex in its aetiology and can be the result of chronic tiredness and/or physical or mental exhaustion) are both found in surgical team members. Both

Before induction of anaesthesia
Ask the patient to confirm his/her identity, procedure, site and consent.
Confirm the operating site has been marked, if applicable.
Confirm the anaesthetic machine and the medication checks are complete.
Confirm the pulse oximeter is working.
Check whether the patient has:

- A known allergy.
- A difficult airway.
- An aspiration risk.

Check the anticipated blood loss, noting particularly if >500 mL (>7 mL/kg for children).

Before skin incision
Team members to introduce themselves by their name and role.
Confirm the patient's procedure and where the incision will be made.
Confirm whether antibiotic prophylaxis has been given or prescribed.
Surgeon to identify:

- Critical or non-routine steps.
- How long the case will take.
- The anticipated blood loss.

Anaesthetist

- Identify any patient-specific concerns.

Nursing and wider theatre team

- Has sterility been confirmed?
- Are there any equipment issues or any concerns?

Imaging

- Has the essential imaging been reviewed, or is it displayed?

Before the patient leaves the operating room
Nurse confirms:

- The completion of instrument, swab and needle count.
- The correct labelling of specimens.
- The identification and reporting of any equipment problems.

Surgeon, anaesthetist and nurse identify key concerns for recovery and management of the patient.

Figure 2.2 The WHO surgical safety checklist.

can reduce complex cognitive tasks, decision-making and situational awareness as well as impairing our technical and physical performance. The value of taking regular short breaks, for example, during a long and complex 8-hour operation is not only beneficial for individuals and teams but may also prevent errors. Most of us would not drive for 8 hours non-stop, so why can it be deemed safe to do so for surgery? One useful fact to remember is that our cognitive function after being awake for 18 hours is like being twice over the UK legal alcohol limit for driving. Increasingly, employing hospitals recognize that tired clinicians are much more likely to make a mistake, not to mention the effects on mood and general well-being. No one else knows how an individual feels, and if they have been operating throughout the night and are expected to work the following day, the few words 'I don't feel safe' can be very powerful when discussing with managerial or other clinical colleagues.

Hydration and nutritional status

Hydration, nutrition and individual recovery are often overlooked human factors but are crucial in the operating theatre to maintain performance. Even small deficits in total body water can have a significant impact on cognitive function, resulting in poorer decision-making, causing sleepiness, apathy, headaches and impatience. For example, a 1–2 kg loss in body water in an average-build individual reduces cognitive function by 15–20%. This tends to happen slowly so that we are not aware our performance is deteriorating. Good

Table 2.1 Simplified Human Factors Analysis and Classification System (HFACS) relevant to surgery

The different levels are analogous to the holes in the Swiss cheese model lining up to cause an error.

Organizational influences within the hospital
- Hospital targets and pressures to deliver results (either perceived or real).
- Climate, process and resource management within the hospital.
- Communication, training and recognition by the senior management of human factors responsible for possible errors.

Unsafe supervision
- Inadequate supervision of trainees or other healthcare staff.
- Failure of briefings/complacency with the WHO checklist.
- Failure of the team to know what to do when things go wrong.
- Loss of situation awareness, especially if not recognized by the theatre team.

Preconditions to unsafe acts
- Fatigue, hunger and nutritional status.
- Emotional influences (anger and personal issues) and running late.
- Tiredness, boredom and communication issues, remember HALT – hungry, anxious/angry, late, tired.
- Environmental factors: background noise, distractions, lighting, ambient temperature and humidity.
- Panic.

Unsafe acts (less likely)
- Unfamiliar with changes from what is seen as a 'normal event'.
- Distracting and multi-tasking.
- Operating outside of one's area of expertise or following a long period of no operating (surgical currency).

hydration is particularly important if personal protective equipment (PPE) is being worn, as this can increase the rate of perspiration and loss of body water. Water requirements are unique to individuals, and while a multitude of factors, including body mass, ambient temperature, pregnancy and diet, play a role, the minimum requirement is approximately 2 L/ day.

Good and balanced nutrition when distributed over a sensible time period also helps optimize personal performance and supports complex mental and physical tasks over a sustained period. An example of this is a well-balanced, small-portioned meal consisting of complex carbohydrates, protein and healthy fats every 3–4 hours. In contrast, large meals eaten over erratic time periods consisting of simple sugars or processed foods are more likely to produce fluctuating energy levels, which can have a detrimental effect on our work. One only needs to look at athletes to realize how effective good nutrition can be on improving performance. Pre-planned breaks during long operating lists, clinics and on-call periods also ensure enough opportunity can be afforded for all team members to recover.

Emotion and stress

Mental perspective and its impact on work performance needs to be recognized. Powerful emotions such as anger or upset can easily interfere with decision-making while performing a task that requires intense concentration. The operating theatre can itself be an environment that can be stressful for members of the surgical team – many would have witnessed colleagues raise their voices or become angry – one of the reasons being a result of stress or other factors that align. During such times, error is far more likely, not to mention the potential effect of loss of civility on the wider team, which can lead to respect being lost, amongst other negative effects.

The value of pausing during an operation (if it is safe to do so) to address these underlying issues may reduce the likelihood of error. We recommend taking a short break, again if it is safe to do so. Bringing the aforementioned factors together, the easily remembered pneumonic HALT – hunger, anger/anxiety, lateness (or lonely), tiredness – is a powerful reminder of the factors that can lead to surgical error as well as recommending the importance of stopping when one or more of these factors arise. Recognizing the impact of stress and emotion not only helps reduce the risk of error but also benefits surgical training and more effective and happier team working, all of which ultimately improve overall patient management. 'Lonely' has also been included as this word introduces the idea of remembering the value of involving colleagues for complex cases or after

Table 2.2 Situations that might increase the chance of an error in the operating theatre environment

Being aware of the following risk factors for error can help improve situational awareness:
- High physical or mental workloads.
- Interruptions and distractions during key parts of an operation.
- Tasks requiring an 'out of normal' response and/or unanticipated new tasks.
- Multi-tasking.
- Changes in physical environment.

a prolonged period of no operating (during COVID-19, for example). Dual surgeon operating can be very useful in this regard, and not only can this give surgeons confidence, but it can also improve patient outcomes.

Situational awareness

A simple definition of situational awareness is being aware of what is going on around us. Awareness and appreciation of several factors that increase the risk of medical error (Table 2.2) can be used to help improve situational awareness for both individuals and the whole team. Situational awareness is dynamic and can change quickly.

An important concept to be aware of is how situational awareness can change or degrade over time in different circumstances and our ability (or not) to adapt to it. Scenarios in which a surgeon may become fixated on a task, develop tunnel vision and become blind to other factors may readily occur. Surgeons can lose their situational awareness, especially if they have confirmation bias in which they are looking for clues or information to confirm the direction they are following. This could include convincing oneself of an anatomical structure or location when it is something quite different. As a result, many errors have occurred, including, for example, cut bile ducts, ureters and important nerves.

Recognizing the value of situational awareness alongside a well-briefed and subsequently de-briefed team, all of whom feel safe and able to voice their concerns, provides the best environment to reduce the risk of medical error taking place· This way, team members are looking out for each other, thereby improving safety and more effective working. By actively thinking ahead (having the best situational awareness), an error can often be avoided. For example, the best drivers are those who anticipate problems early, thereby avoiding potentially hazardous situations. In a similar way, thinking and discussing with the team about any potential 'what if?' scenarios before an operation commences can reduce the likelihood of a startle reaction and ensures the team is best prepared.

Patient, Procedure, People

The concept of Patient, Procedure, People (PPP) has recently been introduced. Essentially, it is an adaptation of the aviation mnemonic, aviate, navigate, communicate (ANC). This is a useful way of regaining situational awareness when something does not seem quite right. In some circumstances, it may be the procedure that needs re-discussing first, to help regain situational awareness. In most instances, stepping back from the acute situation (if safe to do so) and discussing with the team is the best way to understand the problem and decide the best course of action.

The team brief, lowering authority gradients and ensuring good communication

The team brief

Patient care is rarely, if ever, performed in isolation from other team members. The introduction of the WHO surgical safety checklist (Figure 2.2) and team brief has brought significant improvements to patient safety in theatre. It involves theatre staff standing together and introducing themselves and their roles. The lead surgeon describes the planned procedure, details any anticipated critical events and confirms that the necessary imaging has been reviewed; the anaesthetist identifies any patient-specific concerns; and the nursing staff ensure they know about any special equipment that may be required.

Enhancing team working, understanding, valuing and reducing hierarchy, all contribute towards safer patient outcomes. The way in which a briefing is conducted is important. It should not be rushed, and from the outset, all team members should feel valued equally and empowered to

Table 2.3 Items to consider during a team briefing

A well-prepared team is advantageous, in that every member knows their role and looks out for their colleagues. It can also help team members to feel valued.

Briefing
Introductions, open culture, 'Please speak up if concerned'.
Leadership, team working and decision-making.
Think about the 'what if?' scenarios that might occur during a procedure.
Identify the major steps and who will be doing what.
Ask 'What am I expected to do if and when something goes wrong?'
Situational awareness – how to intervene when something does not seem right.

Debriefing
A debrief is a powerful way to develop and enhance team working for future operating sessions.
- What went well?
- What should we do differently next time?
- What do you think about my performance today?
- Saying 'Thank you' to the team!

speak up if they have any concerns, without fear of retribution. Table 2.3 provides a summary of items that may be included in both briefing and debriefing sessions. The team brief should also stress the importance of looking out for each other to reduce the likelihood of losing situational awareness and highlighting when factors such as tiredness and stress are observed in others.

Tunnel vision

During periods of intense concentration, surgeons can become tunnel visioned and quickly lose track of time. Several hours can pass, and the reliance on others to keep an eye on the clock and suggest a short break perhaps after 3 hours is good practice.

Distraction

A distraction while you are concentrating can have a negative effect on performance. If there are safety-critical times during the operation, these should be raised at the team brief, and distractions should be kept to a minimum. The sterile cockpit approach (where pilots focus only on flying when below 10,000 ft, with no distractions) is a valuable technique to apply in theatre. A simple distraction such as a telephone call asking for advice during a complex part of an operation significantly raises the risk of error. It is far better to either limit distractions (including noise) during these times or stop and focus on one task at a time instead of multi-tasking.

Debrief

At the end of the operating list, it is good practice to conduct a short debrief. This does not necessarily have to be formal, but it gives an opportunity to discuss what went well and what could be improved next time. The power of saying thank you to the team cannot be emphasized enough. Gaining feedback from other team members on our own performance is also valuable and builds practice and non-technical skills.

Hierarchy

In aviation, the most junior airline pilot is actively encouraged to be able to question the most senior Captain without fear. Similarly, empowering all surgical team members, including medical students, trainees, nurses and non-clinical staff, to voice their concerns ensures a safe working environment for everyone. Of course, there has to be a team leader and hierarchy so that the wider team appreciates who is ultimately responsible. A flat hierarchy is as dangerous as a steep one as no one quite knows who is doing what as there is no leadership. However, what is most important is to know that any team member can speak up, if concerned, without fear and that their concern will be listened to.

Communication

Effective communication between team members is an essential element to good team working and interaction. Ninety percent of communication is non-verbal, so while wearing PPE, instructions may not be heard or understood due to the face being covered and voice being muffled. The regular use of open questions such as: 'What do you think we should do?' and 'What would you suggest here?' are good at bringing the team together. The use of pronouns (e.g. 'pass me *it* or *that*) should be avoided, especially at safety-critical times, and instead, usage of proper nouns to ensure clear instructions (such as the name of a required instrument) is much better. Finally, 'repeat back' is a useful tool to confirm that a message has been heard and understood by the receiver. Just because a team member has said something does not automatically mean that others have heard and understood the message or instruction.

In summary, human factors application is essential to ensure both individuals and teams are best optimized to care for patients. Some elements are just common sense, such as stopping for a short break regularly just as we would do while driving a long distance. However, it can be all too easy to leave common sense at the front door of the hospital when we come to work.

3

Fluid and nutrition management

Lynsey Spillman

Learning objectives

- ✓ To understand the distribution and composition of body fluids and how these may change following surgery.
- ✓ To understand the role of perioperative nutrition.

The management of a patient's fluid status is vital to a successful outcome in surgery. This requires preoperative assessment, with resuscitation if required, and postoperative replacement of normal and abnormal losses until the patient can resume a normal diet. This chapter will review the normal state and the mechanisms that maintain homeostasis and will then discuss the aberrations and their management.

Body fluid compartments

In an 'average' person, water contributes 60% to the total body weight: 42 L for a 70 kg man. Forty percent of the body weight is intracellular fluid, while the remaining 20% is extracellular. This extracellular fluid can be subdivided into intravascular (5%) and extravascular or interstitial (15%). Fluid may cross from compartment to compartment by osmosis, which depends on a solute gradient, and by filtration, which is the result of a hydrostatic pressure gradient.

The electrolyte composition of each compartment differs (Figure 3.1). Intracellular fluid has a low sodium and a high potassium concentration. In contrast, extracellular fluid (intravascular and interstitial) has a high sodium and low potassium concentration. Only 2% of the total body potassium is in the extracellular fluid. There is also a difference in protein concentration within the extracellular compartment, with the interstitial fluid having a very low concentration compared with the high protein content of the intravascular compartment.

Knowledge of fluid compartments and their composition becomes important when considering fluid replacement. In order to fill the intravascular compartment rapidly, a plasma substitute or blood is the fluid of choice. Such fluids, with high colloid osmotic potential, remain within the intravascular space, in contrast to a crystalloid solution such as compound sodium lactate (Hartmann's[1]) solution, which will distribute over the entire extravascular compartment, which is four times as large as the intravascular compartment. Thus, of the original 1 L of Hartmann's solution, only 250 mL would remain in the intravascular compartment. Five percent

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[1] Alexis Frank Hartmann (1898–1964), Professor of Paediatrics, St Louis Children's Hospital, St Louis, USA. Hartmann added sodium lactate to a physiological salt solution that was developed by Sydney Ringer (1834–1910), Professor of Materia Medica and Therapeutics, University College Hospital, London, and formerly also a physician at Great Ormond Street, London.

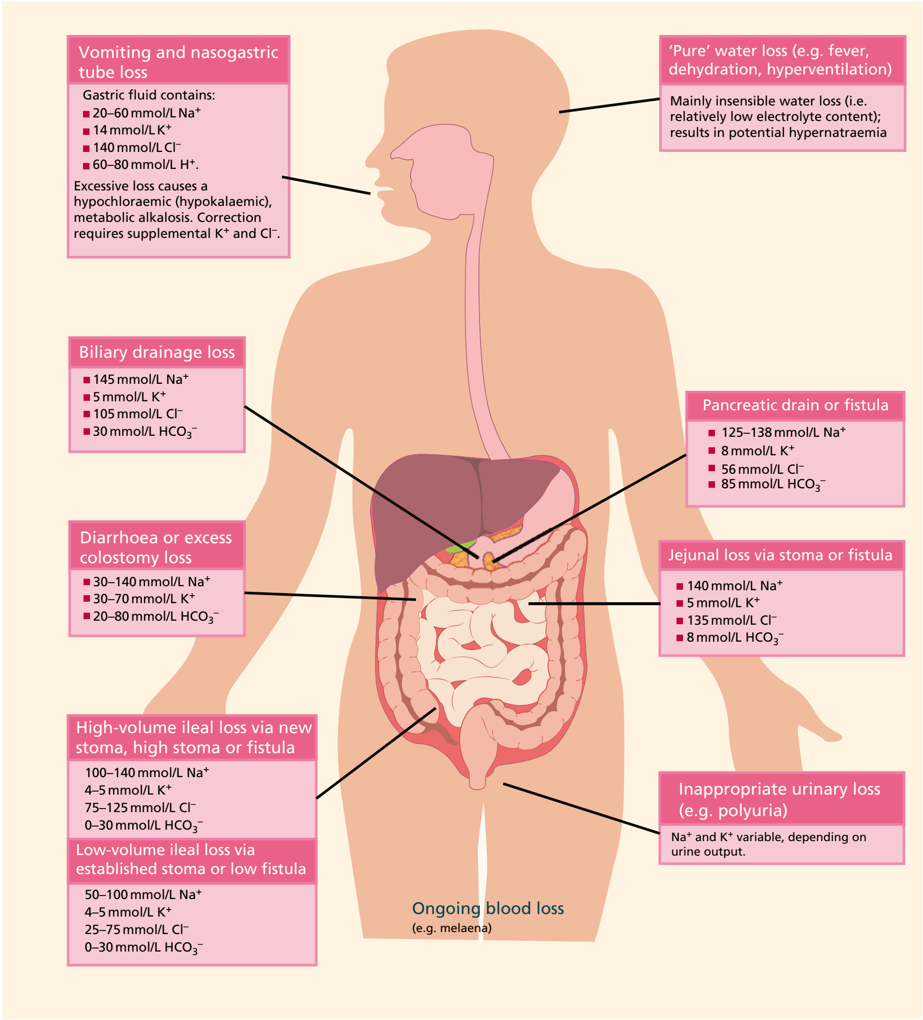

Figure 3.1 Estimated electrolyte concentration in body fluids encountered post surgery.
Source: From National Institute for Health and Care Excellence (NICE) https://www.nice.org.uk/guidance/cg174/chapter/1-recommendations

dextrose, which is water with 50 g of dextrose added to render it isotonic, will redistribute across both intracellular and extracellular spaces.

Fluid and electrolyte losses

In order to calculate the daily fluid and electrolyte requirements, the daily losses should be measured or estimated (Figure 3.1). Fluid is lost from four routes: the kidney, the gastrointestinal tract, the skin and the respiratory tract. Losses from the last two routes are termed insensible losses. In addition, losses from surgical drains should be accounted for. Weighing the patient daily can give a good indication of overall changes in fluid balance.

Normal fluid losses

The kidney

In the absence of intrinsic renal disease, fluid losses from the kidney are regulated by aldosterone and antidiuretic hormone (ADH). These two hormone

Table 3.1 Normal daily fluid losses

Fluid loss	Volume (mL)	Na^+ (mmol)	K^+ (mmol)
Urine	2,000	80–130	60
Faeces	300		
Insensible	400		
Total	2,700		

systems regulate the circulating volume and its osmolarity, and are thus crucial to homeostasis. Aldosterone responds to a fall in glomerular perfusion by salt retention. ADH responds to the increased solute concentration by retaining water in the renal tubules. Normal urinary losses are around 1,500–2,000 mL/day (Table 3.1). The kidneys control water and electrolyte balance closely and can function in spite of extensive renal disease. Damaged kidneys leave the patient exquisitely vulnerable to inappropriate water and electrolyte administration.

The gastrointestinal tract

The stomach, liver and pancreas secrete a large volume of electrolyte-rich fluid into the gut. After digestion and absorption, the waste material enters the colon, where the remaining water is reabsorbed. Approximately 300 mL is lost into the faeces each day.

Insensible losses

Inspired air is humidified in its passage to the alveoli, and much of this water is lost with expiration. Fluid is also lost from the skin, and the total of these insensible losses is around 700 mL/day. This may be balanced by insensible production of fluid, with around 300 mL of 'metabolic' water being produced endogenously.

Abnormal fluid losses

The kidney

Most of the water filtered by the glomeruli is reabsorbed in the renal tubules, so impaired tubular function will result in increased water loss. Resolving acute tubular necrosis (Chapter 43), diabetes insipidus and head injury may result in loss of several litres of dilute urine. In contrast, ectopic production of ADH by tumours (the syndrome of inappropriate ADH, or SIADH) causes water retention and haemodilution.

The gastrointestinal tract

Loss of water by the gastrointestinal tract is increased in diarrhoea and in the presence of an ileostomy, where colonic water reabsorption is absent.

Vomiting, nasogastric aspiration and fistulous losses result in loss of electrolyte-rich fluid. Disturbance of the acid–base balance may also occur if predominantly acid or alkaline fluid is lost, as occurs with pyloric stenosis and with a pancreatic fistula, respectively.

Large occult losses occur in paralytic ileus and intestinal obstruction. Several litres of fluid may be sequestered in the gut, contributing to the hypovolaemia. Resolution of an ileus is marked by absorption of the fluid, and the resultant hypervolaemia produces a diuresis.

Insensible losses

Hyperventilation, as may happen with pain or chest infection, increases respiratory losses. Losses from the skin are increased by pyrexia and sweating, with up to 1 L of sweat per hour in extreme cases. Sweat contains a large amount of salt.

Effects of surgery

The stress response to surgery includes the release of ADH/vasopressin and catecholamines and activation of the renin–angiotensin system, resulting in oliguria and water retention. In spite of oliguria, the patient may be euvolaemic, hence the need to fully assess the state of hydration before prescribing postoperative fluids. Unnecessary administration of saline, for example, may expand the blood volume and thus reduce the haematocrit; overexpand the interstitial space, resulting in oedema; and provide a salt load that the patient cannot excrete.

Potassium is released by damaged tissues, and its concentration may be further increased by blood transfusion, each unit typically containing in excess of 10 mmol. If renal perfusion is poor and urine output sparse, this potassium will not be excreted and instead accumulates; the resultant hyperkalaemia causes life-threatening arrhythmias. This is the basis of the recommendation that supplementary potassium may not be necessary in the first 48 hours following surgery or trauma.