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A Task Analysis of Anaesthetic Practice

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2	March 2010	Second release version: HTA, GEMS, SHERPA and SGT analyses
2.1	March 2010	Version 2 with corrections to errors in the data presented
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Contents

Abstract

A human reliability analysis of anaesthetic practice was carried out in order to facilitate discussion of the human factors issues that affect anaesthetists in their work. The analysis used a combination of Hierarchical Task Analysis (HTA), the Systematic Human Error Reduction and Prediction Approach (SHERPA), the Generic Error Modelling System (GEMS) and the Sub-Goal Template (SGT) to identify potential human errors that could occur during anaesthesia and provide suggestions as to how they could be mitigated. This report describes the methodology used and provides the results of the analysis in their entirety, in order to inform both anaesthesia practice and further research in patient safety.

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1. Introduction

1.1. Aim of report

This report has been produced from a research project undertaken at the University of Manchester, investigating procedural violations in anaesthesia (funded by the Engineering and Physical Sciences Research Council, 2005-2008). Its aim is to describe work carried out during the initial stages of the project to apply a human reliability analysis to anaesthesia practice. This work will be used to inform future research by the authors, as well as being made available (both through this report and through summaries to be published in the academic literature) to other researchers and practitioners.

1.2. Background

Human factors in anaesthesia

Anaesthetic practice has long been recognised as a 'high risk' activity, and as such has been the subject of a substantial amount of research examining the effect of human factors on its safety and effectiveness [1]. Cooper et al. [2] carried out a retrospective analysis of 359 anaesthetic accidents which had been thought to be preventable, and concluded that 82 percent of them were attributable – at least in part – to human error. This would suggest that there is some value in examining in more detail what happens within anaesthesia, and how the process of anaesthesia interacts with human factors. One review on this topic [3] has identified a wide range of factors that could affect the performance of anaesthetists. These include:

- *The work environment.* Physical characteristics of the work environment, for example noise, temperature and lighting;
- *The human component*. Characteristics of the anaesthetic team. These may be transient (for example, fatigue or workload) or pervasive (for example, training and experience);
- *The equipment.* Characteristics of the equipment with which the team work (for example, the design of monitors and alarms).

Given the attention paid by this anaesthesia to human factors issues, there would appear to be a case for making a detailed examination of the anaesthetic task. This paper proposes that a common ergonomics methodology known as human reliability analysis would be of value to those interested in patient safety in anaesthesia.

Human reliability analysis

The aim of human reliability analysis (HRA) is to examine a work activity in order to identify potential human errors. This is sometimes carried out retrospectively (for example, in incident investigation) but is usually conducted prospectively to anticipate human errors for the purpose of training or work design. There is a range of HRA methods, each of which takes a different approach to characterising human performance and error; however, they generally proceed by systematically examining the tasks involved during a work activity and the context within which these tasks are carried out [4, 5]. Human reliability analysis has been employed in several 'high risk' industries, most notably nuclear and chemical process control [5, 6] and transportation [7-9]. It has also had more generic application in the examination of human-machine interaction with a variety of devices [10, 11]. Within healthcare, the use of human reliability analysis is not yet widespread, but is becoming increasingly familiar [12, 13]. It has been most enthusiastically taken up in surgical and pharmaceutical [14-17] domains, although it is not yet widely used in anaesthesia.

Systematic Human Error Reduction and Prediction Approach (SHERPA)

One HRA method that is becoming increasingly popular is the Systematic Human Error Reduction and Prediction Approach (SHERPA). This was devised during the 1980s for use in nuclear process control [18], but has since found use in a wide variety of other domains, including healthcare [7, 11, 15, 16]. The SHERPA process consists of two stages:

1. The work activity under examination is decomposed using a standard Hierarchical Task Analysis (HTA) [19, 20]. This starts with an overall task goal and then iteratively breaks this down into a hierarchy of task

steps, accompanied by a description of how these task steps are conducted in pursuit of the task goal. The process continues until a suitable level of granularity has been reached (typically, this is when the task steps are at the level of discrete actions). An illustration of a simple task analysis is shown in Figure 1.1;

2. The lowest-level task steps are examined using a behavioural taxonomy. This taxonomy (shown in Table 1.1) identifies the class of behaviour that is being performed at each task step, and the types of error that are associated with that behaviour. The analyst then selects appropriate errors from the list, determines the impact and likelihood of each, and provides suggestions as to how they can be dealt with.

Figure 1.1: An example of a hierarchical task analysis, showing the initial decomposition (top) and then a further decomposition of one of the sub-goals (bottom).

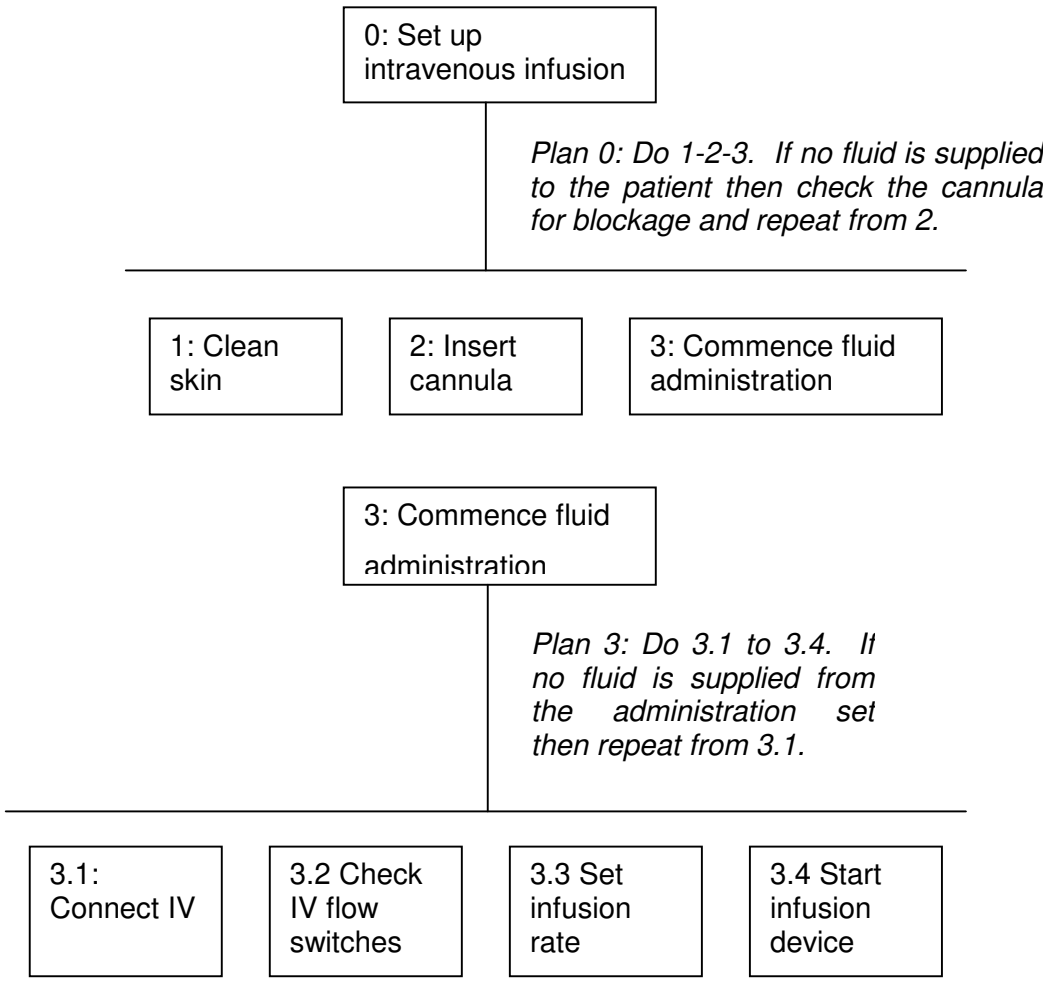

Table 1.1: SHERPA error mode taxonomy

Class of behaviour	Type of error
Action	A1 – Too long or too short
	A2 – Mistimed
	A3 – Wrong direction
	A4 – Too little or too much
	A5 – Misaligned
	A6 – Right action, wrong object
	A7 – Wrong action, right object
	A8 – Action omitted
	A9 – Action incomplete
	A10 – Wrong action, wrong object
Check	C1 – Check omitted
	C2 – Check incomplete
	C3 – Right check, wrong object
	C4 – Wrong check, right object
	C5 – Check mistimed
	C6 – Wrong check, right object
Retrieval	R1 – Information not obtained
	R2 – Wrong information obtained
	R3 – Information retrieval incomplete
Communication	I1 – Information not communicated
	I2 – Wrong information communicated
	I3 – Information communication incomplete
Selection	S1 – Selection omitted
	S2 – Wrong selection made

It is considered to be a relatively comprehensive and flexible HRA method, yet is also comparatively straightforward to carry out [21-23]. Also, there is some empirical evidence for its reliability and validity in the prediction of human errors that occur during actual task execution. One study found that SHERPA achieved a good level of inter-rater reliability when carried out by two assessors working independently, and of concurrent validity when used to predict the errors that would be observed in the use of a ticket machine [11]. It has also been found to have a consistent level of accuracy over a number of

administrations when used by a group of novice analysis to predict the errors that would occur when using a vending machine [23]. Within the aviation domain, a SHERPA analysis of flight-deck behaviour during an aircraft landing has been found to correspond with self-reports of actual errors [7].[1] At the time of writing, no formal assessment of reliability or validity has been conducted in the medical domain, but researchers have used a derivative of SHERPA to retrospectively classify errors that were observed during endoscopic surgery [15]. Because of the evidence for its usability and effectiveness, and particularly its successful use in other medical domains, SHERPA has been adopted as a suitable HRA method for the current study.

Generic Error Modelling System (GEMS)

As well as SHERPA, a complementary approach known as the Generic Error Modelling System (GEMS) will be used. This was proposed by Reason [24, 25] as a conceptual model of human error. It is based on Rasmussen's [26] SRK model of human performance, which classifies behaviour as being either *skill-based* (that is, associated with routine, learned actions), *rule-based* (associated with rule- or heuristic-driven responses to problems) or *knowledge-based* (associated with reasoning about problems for which there is no obvious response). As Figure 1.2 shows, each 'level' of performance involves progressively more cognitive effort, and is invoked if the person is unable to perform at the previous level. For example, a machine operator performing routine tasks might perform at the skill-based level with little conscious control; however, if a problem occurs (for example, the machine malfunctions) then the operator may initially attempt to apply a known rule,

[1] One issue that has been identified during some of these studies is a tendency for SHERPA to identify errors that are either not likely or not credible [22, 23]. Of the three studies discussed, it was the study involving novices with the least level of training [23] in which false alarms were most prevalent. It is not clear to what extent this would affect analyses in practice; in the absence of any systematic examination of this issue, it is suggested that those analysts who are aware of the tendency for SHERPA to generate 'false alarms', and who know enough about the domain under study to make a judgement about the credibility of the error modes identified, will be less prone to this problem. However, it has been noted as a caveat to SHERPA's use [22].

perhaps in the form of established emergency procedures or an informally-acquired ‘rule of thumb’ for dealing with the situation. Should this not be successful, or there is no known rule to apply, then the operator would then have to engage in more deliberate problem solving at the knowledge-based level, which would involve drawing upon relevant knowledge to formulate a novel solution. The GEMS framework links these levels of performance to error types and error-provoking factors, as shown in Table 1.2.

The GEMS framework has been used to classify and describe human error in surgery [27] and anaesthesia [28, 29]. In particular, it provides the following insights into human error:

i) The type of errors that are prone to occur at any given point would depend on which level of performance the actor is in at the time. As Table 1.2 shows, skill-based errors tend to take the form of a ‘slip’ or ‘lapse’ (where an otherwise correct action is executed incorrectly or something is forgotten), rule-based errors are characterised as ‘mistakes’ (where an incorrect action is executed), while knowledge-based errors are also ‘mistakes’ but of a different kind (where the actor’s rationale for selecting actions to execute is incorrect).

ii) A corollary of (i) is that the remediation for each error depends on the level of performance that is active when the error takes place [27]. This is one of the fundamental principles behind the ‘ecological’ approaches to work design recently proposed by Rasmussen [30] and Vicente [31]. In addition, Walsh and Beatty [32] suggest that many human factors errors arise in the use of medical monitoring equipment because the actor is working at the ‘wrong’ level – for example, he or she fails to recognise that the situation has deviated from a normal routine (hence a need to move from skill-based to rule-based behaviour) or that the situation is sufficiently novel as to require knowledge-based behaviour [4]. This would suggest that one intervention could be to ensure that the actor is working at the appropriate level, for example, through training or by using an automated reminder.

Figure 1.2: Outline of the GEMS mechanism [32]

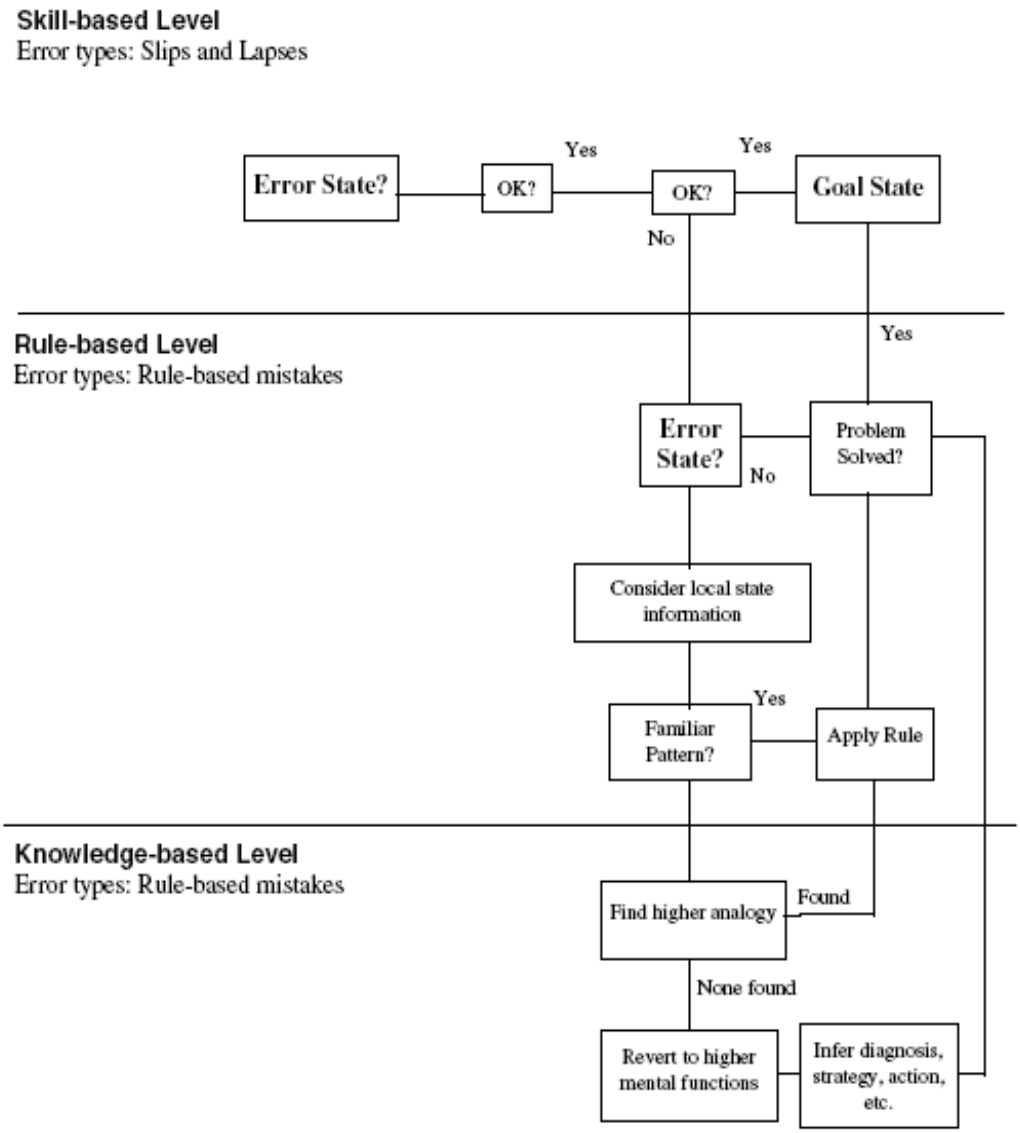

Table 1.2: Error modes and error-provoking factors in GEMS [24, 25]

Level of performance	Error types	Error-provoking factors	Example
Skill	Skill-based slips: • Inattention (omitted behaviour) • Overattention (mistimed behaviour) Skill-based lapses • Memory failures	Recency and frequency of previous use Environmental cues Shared schema properties Concurrent plans	Accidentally inserting an endotracheal tube into the patient's oesophagus Forgetting to apply a blood pressure monitor during induction
Rule	Rule-based mistakes: • Misapplication of good rules • Application of bad rules	Mind set ("it's always worked before") Availability ("first come best preferred") Matching bias ("like relates to like") Oversimplification (e.g. 'halo' effect) Overconfidence ("I'm sure I'm right")	Using the incorrect type of tube for intubation
Knowledge	Knowledge-based mistakes • Selection of an inappropriate course of action ('satisficing')	Limitations in human problem-solving ability, for example: • Selectivity • Working memory overload • Availability ("out of sight, out of mind") • Problems with causality and complexity • Memory cueing / reasoning by analogy • Cognitive biases (e.g. confirmatory bias) • Incomplete or incorrect mental model	Failing to recognise the anaesthetic implications of a given situation and providing sub-optimal care as a result

It has been suggested previously that SHERPA and GEMS could be conducted in parallel, as GEMS is better able to account for cognitive errors, particularly at the knowledge-based level [4]. Indeed, the earliest versions of

SHERPA included a consideration of the level of performance as well as the error taxonomy listed in Table 1.1 [18]. However, the use of GEMS has not been widely adopted for two main reasons. Firstly, some of the errors considered by GEMS are quite complex both to assess and to remedy, hence few, if any, attempts appear to have been made to formulate or evaluate GEMS as a practical HRA tool [4, 21]. Secondly, analysis of the level of performance and its associated error mechanisms was removed from later revisions of SHERPA due to a difficulty in achieving a one-to-one mapping between these and the 'external' error modes in Table 1.1; in practice, a given error mode can be produced by more than one of the 'internal' mechanisms represented by the level of performance. This means that it is of limited value to HRA practitioners, although it remains an issue of potential interest to researchers as well as designers [32, 33].

Sub-Goal Template (SGT)

The SGT was designed to produce requirements specifications from a task analysis, for example when defining the design requirements for new equipment [34]. It is intended to be carried out as part of a HTA; after the initial task decomposition, SGT provides a set of task elements to be appended onto any subtasks that involve an interaction between the user and a system. These task elements categorise the type of interaction that occurs during a given task step, from which the information requirements – the data or information that needs to be presented to the user – can be inferred (see Table 1.3).

Table 1.3: Task elements for SGT (adapted from [35])

Sub-Goal Templates	**Task elements**	**Context**	**Information requirements**
Act	Perform as part of a procedure or subsequent to a decision made about changing the system		
	A1 Activate	Make subunit operational: switch from off to on	What states does the subunit progress through during activation?
	A2 Adjust	Regulate the rate of operation of a unit maintaining "on" state	What is the rate of change of operation in response to an adjustment?
	A3 Deactivate	Make subunit nonoperational: switch from on to off	What indicates deactivation?
Exchange	To fulfil a recording requirement. To obtain or deliver operative value		
	E1 Enter	Record a value in a specific location	What is the data range? Does it consist of continuous or discrete variables?
	E2 Extract	Obtain a value of a specified parameter	Where is the data stored / retrieved? How is the actor prompted?
Navigate	To move to an informational state for exchange, action or monitoring		
	N1 Locate	Find the location of a target value or control	Where can the target be found, and what is it?
	N2 Move	Go to a given location and search it	Where can the target be found, and what direction should the actor search in?
	N3 Explore	Browse through a set of locations and values	What are the items to be browsed through?
Monitor	To be aware of system states that determine need for navigation, exchange, and action		
	M1 Monitor to detect deviance	Routinely compare system state against target state to determine need for action	What are the normal parameters for comparison?
	M2 Monitor to anticipate cue	Compare system state against target state to determine readiness for known action	What is the cue to be anticipated?
	M3 Monitor transition	Routinely compare rate of change during state transition	Against what are observed parameters being compared?

The authors of the sub-goal template have demonstrated its use in plant process control and railway supervisory control [35,36]. Ormerod et al. [36] evaluated the usability of SGT with novice task analysis, and found that it was particularly helpful when analysing relatively complex process control tasks. However, the SGT is still being refined; the latest version incorporates changes that are intended to make it applicable in settings other than process control, as well as improving its general usability [35]. The SGT appears to be a promising method for elucidating the cognitive aspects of a task during a HTA, but there as yet few field studies using the technique.

Given the foregoing issues, it was decided to analyse the level of performance and sub-goal templates alongside SHERPA. This is being done to facilitate both a discussion of the conceptual nature of anaesthesia practice and an assessment of the value added by GEMS and SGT in the practical analysis of human performance and error.

1.3. Structure of the report

This first section of the report has introduced the study and described the rationale for carrying out a human reliability analysis of anaesthesia practice. In section 2, the process of carrying out the human reliability analysis is described. Section 3 shows the output from this analysis. Section provides some overall discussion about the analysis and some suggestions about its potential uses.

2. The analytical process

2.1. Hierarchical task analysis

A hierarchical task analysis was undertaken of the preparation and administration of anaesthesia. This analysis covered all of the anaesthetist's activities from the start of the pre-operative visit to the post-operative handover of the patient to the recovery staff. In order to conduct the analysis, data was gathered from the following sources:

- *Literature.* In order to provide a theoretical background and ensure full coverage of anaesthesia tasks, relevant training materials and manuals were consulted. These included in-house training materials, published textbooks [37,38] and practice guidelines [39];
- *Observations.* Having obtained institutional and NHS REC approval,[2] two of the researchers (DP, a human factors researcher, and CN, a biomedical engineering researcher) observed anaesthetic teams performing pre- and peri-operative tasks at an adult teaching hospital and a paediatric specialist hospital. The researchers were present for several types of list at both hospital, and in total observed approximately 200 hours. The types of list observed are shown in table 2.1.

Table 2.1: Operating lists observed during the task analysis

Site 1 (Paediatric)	Site 2 (General teaching)
Cleft palate	Dental
Gastroscopy	Ear, Nose and Throat
General	General
Orthopaedics	Gynaecology
Urology	Maxillo-facial
X-Ray (Cardiology catheters)	Plastics
	Trauma
	Urology

[2] Ethical approval for conduct in the NHS was granted by the Central Manchester Research Ethics Committee and the Salford and Trafford Local Research Ethics Committee [COREC project no. 06/Q1407/16].

The data obtained from both sources was synthesised and used to perform a HTA in conjunction with another member of the research team (GHM, an experienced consultant anaesthetist). The procedure for carrying out the analysis followed the standard HTA process [19, 20], which can be summarised as follows:

1. Identify the overall *goal* of the task;
2. Identify the behavioural steps that contribute to the goal. These are termed the *sub-goals*;
3. Having identified the sub-goals, define the circumstances under which each is carried out and the order in which they are conducted. This is known as the *plan*; and is included in the output;
4. Determine whether each sub-goal needs to be described in further detail (that is *decomposed*). The 'rule of thumb' for making this decision is to consider both the likelihood of the sub-goal being performed incorrectly ('Probability') and the consequences of incorrect performance ('Cost'). This is known as the 'P x C' rule. If the cross product of the two is high in the opinion of the subject-matter expert, then this serves as an indicator that the sub-goal may need to be decomposed;[3]
5. If a sub-goal needs to be decomposed, repeat from 2 for that sub-goal;
6. Decomposition ends when a sufficient level of detail is reached. This is to some extent a matter for judgement; in this study, 'sufficient' detail was achieved when either (a) the P x C 'score' was low; (b) the subgoal could not be decomposed meaningfully (i.e. they were already at the level of discrete actions).

[3] It is acknowledged in the literature that the P x C rule, while a good approximation, is not perfect. [20] Amongst other problems, in practice it is often difficult to quantify P and C for a given behaviour, particularly if the domain under study has never been examined in this way before. In this study, the subject matter expert was simply required to rate P and C as being either 'low' or 'high' for a given behaviour.

2.2 SHERPA analysis

Following the task analysis, the task steps at the bottom of the hierarchy were examined in further detail using SHERPA. The procedure employed was that described by Stanton et al. [22], as follows:

1. Classify the behaviour involved, from the following: *action* (e.g. pressing a button); *retrieval* (e.g. getting information); *checking* (e.g. conducting a procedural check); *selection* (e.g. choosing one alternative over another); *information communication* (e.g. talking to another party);
2. Using the error mode taxonomy shown in Table 1.1, determine the credible errors that can occur;
3. Describe the consequences associated with each error;
4. Determine the 'recovery potential' of each error, noting any steps that occur later in the HTA where the error could be recovered (that is, identified and corrected before it has an effect);
5. Rate the probability of each error occurring, including instances where the error occurs but is 'recovered'. The probability is classified as low (hardly ever occurs), medium (occasionally occurs) or high (frequently occurs);[4]
6. Rate the criticality of each error – low, medium or high[5]
7. Suggest prospective remedial strategies to prevent the error from occurring or promulgating (equipment, training, procedures or organisational).

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[4] Objective estimates for these values are not available in the literature, and extracting them from available critical incident reports assumes that the error in question was always explicitly identified in the reports. Therefore, as a guide to determining the probability, 'low' was taken to represent an estimated probability of 1 in 1000 or less, 'medium' an estimated probability of between 1 in 1000 and 1 in 100, and 'high' an estimated probability of 1 in 100 or greater.

[5] As a guide to determining criticality, 'low' was taken to represent a barely noticeable effect; 'medium' a noticeable but transient effect; and 'high' a potentially life-threatening or permanent effect.

The HTA and SHERPA were subsequently reviewed by three subject matter experts who were external to the research team. These included a surgical clinical research fellow (Mr. Sudip Sarker, Imperial College London), an academic human factors specialist (Prof. Neville Stanton, Brunel University) and a professor of anaesthesia (Prof. Jan Davies, University of Calgary).

2.3 GEMS and SGT analyses

In addition to the SHERPA analysis, each task step was classified according to whether it was primarily skill-based, rule-based or knowledge-based. As a guide to making the classifications, the decision tree from the original version of SHERPA (shown in Figure 2.1) was used. This was originally developed in the context of nuclear process control, but the version shown here has been adapted to use terminology that is more relevant to anaesthesia. As a general guideline for the application of GEMS in this study:

- simple psychomotor tasks, such as operating switches, are usually designated as skill-based;
- monitoring and administering are usually designated as rule-based unless no decisions are required about settings or critical values (for example, “administer 100% oxygen”);
- diagnosis and planning are usually designated as rule-based, unless there are no “rules of thumb” that can be applied, in which case they become knowledge-based.

At this point, it is worth clarifying that the SRK framework is intended to describe, rather than suggest a psychological mechanism for, task behaviour [26, 40]. Unlike theories of skill acquisition [41], SRK does not assume that task behaviour progresses from knowledge to rules to skills as the anaesthetist becomes more expert at the task, and so the designation of some task steps as skill-based and others as knowledge-based does not imply that the former are more ‘established’ than the other or vice-versa. This also means that the three levels are not mutually exclusive and, while most task steps can be considered to operate primarily at one level, there are some which can be assigned to more than one level [31]. For example, attaching a

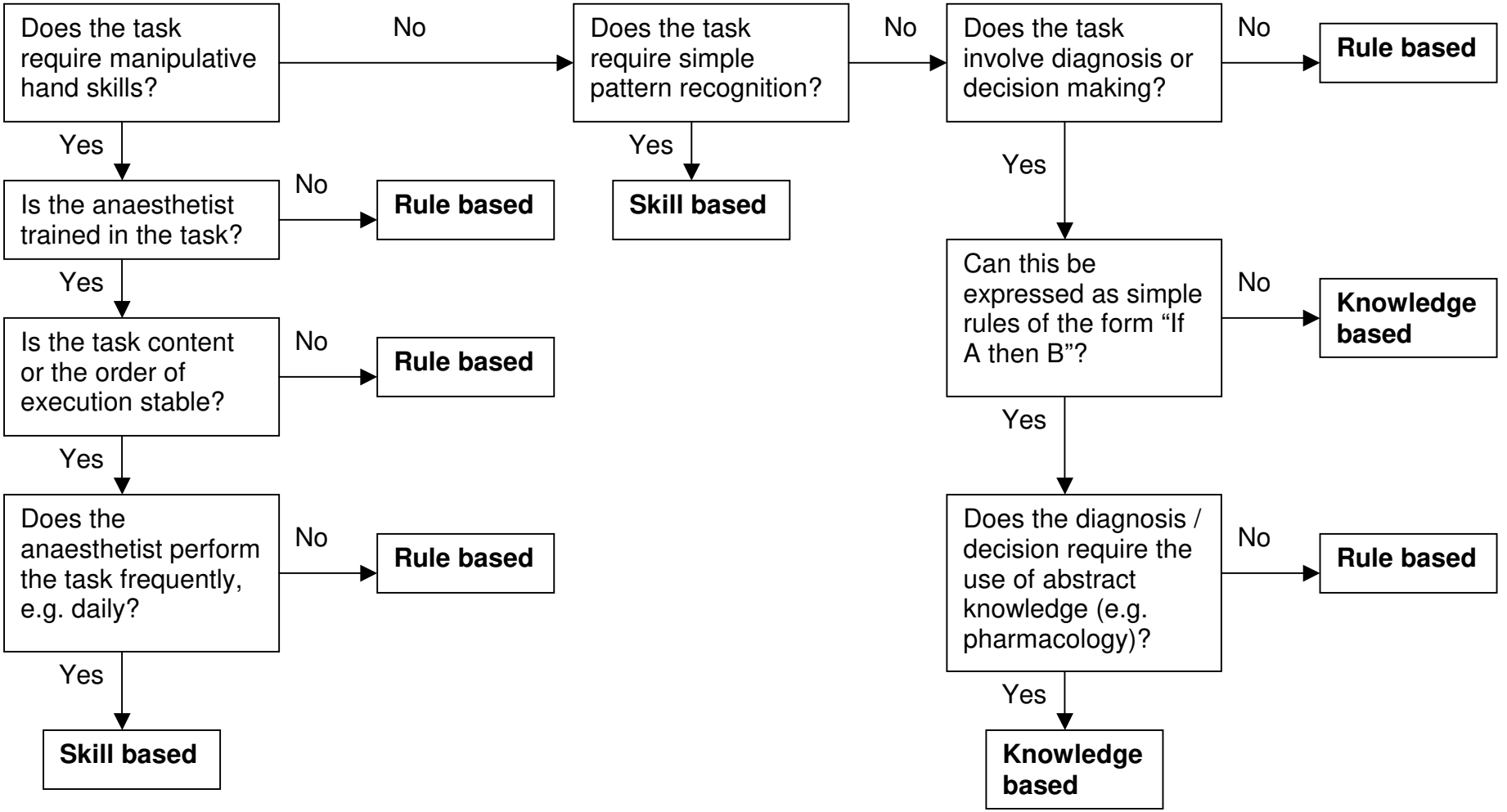
monitor may depend both on the correct placement of the monitor (skill-based) and its settings being correct (rule-based).

The procedure for applying SGT was taken from the guidelines provided by Ormerod and Shepherd [35]. These suggest the following steps for applying SGT to a HTA:

1. At the point that a subtask involves an "information-handling operation" (that is, receiving information, evaluating information and acting on information) designate this subtask as an IHO and decompose it into relevant subtasks (e.g. "obtain current state of system"; "compare current with target states"; "make adjustment")
2. Write the plan using one of the following sequence elements:
    a. Fixed sequence (S1: "Do X");
    b. Contingent sequence (S2: "If a then do X; If not a then do Y");
    c. Parallel sequence (S3: "Do together X; Y");
    d. Free sequence (S4: "In any order do X; Y")
3. For each of the subtasks that comprise an IHO, assign a task element from those listed in Table 1.3.
4. Determine the information requirements that are associated with this task element, and how they are fulfilled in practice, using column 3 of Table 1.3 as a guideline.

The GEMS and SGT classifications were performed initially by one of the researchers (DP) and the subject matter expert (GHM). The classifications were then reviewed by another researcher (PCWB, a human factors researcher with a background in health physics).

Figure 2.1: Decision tree for allocating a level of performance to each task step (adapted from Embrey [18]).



3. Output of the analysis

3.1 Overview

The task analysis is presented in two parts. The first part covers the delivery of pre-operative care (which includes pre-operative planning and assessment), while the second part covers the delivery of peri-operative care (which includes the in-theatre tasks from pre-operative machine checking to patient handover post-operatively). Pre-operative care contains 25 task steps with 16 information exchanges and 25 potential error modes, while peri-operative care contains 176 steps with 101 information exchanges and 201 potential error modes.

A note on presentation of the analysis

The HTA tables will be presented in a tabular format, with the different levels of the task hierarchy indicated by indentation of the text. Task steps will be indicated by bold text, while the plan for each hierarchical level is shown in italics. The SHERPA, GEMS and SGT will be presented in a combined table, as shown in Table 3.1. A colour-coding scheme will be applied to the SHERPA output as follows:

- *Red* denotes error modes that have high probability and criticality;
- *Amber* denotes error modes that have at least medium probability and/or criticality;
- *Green* denotes error modes that have low probability and criticality.

Table 3.1: Key to SHERPA, GEMS and SGT tables

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Type of behaviour, which will be one of: • *Action* • *Retrieval (of information)* • *Checking* • *Selection* • *Communication*	GEMS level – one of: • *Skill* • *Rule* • *Knowledge*	The nature of the error under consideration. The errors identified will depend on the class of behaviour that has been applied	The potential consequences of the error	When and how the error might be picked up and corrected, if at all	Probability of the error occurring (low – 1 in 1000; medium – 1 in 100; high – 1 in 20)	Criticality of the error (low – barely noticeable, medium – noticeable but transient, high – potentially life threatening or permanent)	Candidate interventions to reduce the probability of the error occurring in the first place (whether equipment, training, procedures or policy / culture)

Information exchange	Details
Type of information exchange, which will be one of the task elements listed in Table 1.3	Sources of data for the information exchange or, in the case of an interaction between the anaesthetist and an item of equipment, the response made by that equipment

3.2 Pre-operative care

The HTA output for pre-operative care is shown in Table 3.2. The SHERPA and GEMS output is shown in Table 3.3.

Table 3.2: HTA of pre-operative care. The hierarchical levels are indicated by text indentation. Task steps are in bold text, while plans are in italic text

0: Provide preoperative care

Plan 0

S4 Do in any order 1-3.

S1 Throughout do 4.

S2 For paediatric patients do 5.

1. Assess patient

Plan 1:

S4 Do in any order 1.1 – 1.3. As required, do 1.4

1.1 Assess surgical procedure

Plan 1.1:

S3 Do at the same time 1.1.1 – 1.1.4

1.1.1 Identify type of surgery

1.1.2 Identify site of surgery

1.1.3 Identify grade of surgery

1.1.4 Identify special considerations

1.2 Assess medical history

Plan 1.2:

S3 Do at the same time 1.2.1 – 1.2.5

1.2.1 Determine patient's age

1.2.2 Assess for concurrent medical illness

1.2.3 Check current medications/allergies

1.2.4 Check previous anaesthetics/family history of complications

1.2.5 Check fasting

1.3 Perform physical examination

1.4 Decide whether to give premedication

1.5 Prescribe premedication

2. Request investigations

Plan 2:

S4 As required choose any of 2.1 – 2.7

2.1 Request full blood count

2.2 Request urea and electrolytes

2.3 Request coagulation tests

2.4 Request chest radiography

2.5 Request ECG

2.6 Request sickle test

2.7 Request urinalysis

3. Decide on anaesthetic to be used

Plan 3:

S1 Do 3.1 – 3.4. If choices are not satisfactory then repeat from 3.1.

3.1 Choose anaesthetic drugs

3.2 Choose delivery method

3.3 Identify postoperative care

3.4 Agree choices with patient

4. Reassure patient

5. Invite parents to induction

.

Table 3.3: SHERPA and GEMS for pre-operative care

1.1.1 Identify type of surgery

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Skill**	**R1 – Type of surgery not identified**	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L – M**	**M**	**Verbal check Ensure clear and accurate information is provided on the operating list Use nurse pre-operative checklist to confirm correct information has been provided**
		R2 – Type of surgery incorrectly identified (including incorrect theatre lists or consent forms)	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L – M**	**M**	
Information exchange		**Details**					
E2 – Extract		Information is on the operating list, held in the theatre (lists organised by day and theatre). Check with patients / parents or look at consent form or clinic letter. If there is still doubt, check with the surgeon. [Note: Often the operating list contains inaccuracies (e.g. “hernia on one side” rather than “hernia on both sides”) so it’s common to have to check with other sources. Giving an anaesthetic doesn’t rely on exact knowledge of surgery, but the anaesthetist needs to know something about what is being done, and the more he/she knows the better]					

1.1.2 Identify site of surgery

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Skill**	**R1 – Site of surgery not identified**	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**M**	**M**	**Verbal check** **Use nurse pre-operative checklist to confirm correct information has been provided** **Ensure sufficient details are provided on the operating list (e.g. 'laparotomy / colectomy' rather than 'lapraotomy', if the former is meant).**
		R2 – Site incorrectly identified	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**M**	**M**	
Information exchange		**Details**					
E2 – Extract		As for 1.1.1					

1.1.3 Identify grade of surgery (minor, intermediate, major)

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Grade of surgery not identified**	**Inappropriate plan made for anaesthesia**	**Peri-operative care**	**M**	**M**	**Ensure clear and accurate information is provided on the operating list** **Use pre-operative checklist**
Information exchange		**Details**					
E2 – Extract		Inferred from type and duration of surgery and arrangements made by the surgeon for disposal (home, ward, HDU, or ICU?)					

1.1.4 Identify special considerations

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Special considerations not identified**	**Risk factors not identified**	**3.3; Peri-operative care**	**L**	**L – H (depending on what is not identified)**	**Ensure a full history is taken during the pre-operative assessment** **Use electronic patient records and/or electronic aids to pre-operative assessment**
Information exchange		**Details**					
E2 – Extract		Patient history, exam and case notes (e.g. “difficult intubation”). Examples of considerations include equipment, disposal, antibiotic prophylaxis and steroid therapy.					

1.2.1 Determine patient's age and weight

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Skill**	**R1 – Age not identified**	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L**	**H (Paediatrics); L (Adult)**	**Ensure admission form is filled in correctly**
		R2 – Age incorrectly identified	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L**	**H (Paediatrics); L (Adult)**	**Confirm age / DOB with patient**

Information exchange	Details
E2 – Extract	Age – ask patient, check medical records or operating list for DOB Weight – doesn't appear on the operating list. Patient is weighed at check-in and the information recorded on nursing notes. Some anaesthetic forms have a section for nurses to record pre-operative information – this may have the weight on it as well. Could also check the drug admin chart. If not in any of these sources, may have to estimate weight: e.g. for 13 years and below, [(Age + 3) * 5] / 2 gives weight in kg, although this is a linear estimate of a logarithmic relationship between age and weight

1.2.2 Assess for concurrent medical illness

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Assessment not made**	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L**	**L – H (depending on what is not identified)**	**Ensure a full history is taken during the pre-operative assessment Use electronic patient records and/or electronic aids to pre-operative assessment**
Information exchange		**Details**					
E2 – Extract		Medical history; clinical notes; medical exam; presence of medic-aid. Can also ask the patient / parent. May need to consult a medical encyclopaedia in the case of rare conditions. [NB Clinical notes might be held at a different hospital]					

1.2.3 Check current medications/allergies

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Assessment not made**	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L**	**L – H (depending on what is not identified)**	**Ensure a full history is taken during the pre-operative assessment Use electronic patient records and/or electronic aids to pre-operative assessment**
Information exchange		**Details**					
E2 – Extract		As for 1.2.2					

1.2.4 Ask about previous anaesthetics / family history of complications

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Assessment not made**	**Inappropriate plan made for anaesthesia**	**3.3; Peri-operative care**	**L**	**L – H (depending on what is not identified)**	**Ensure a full history is taken during the pre-operative assessment Use electronic patient records and/or electronic aids to pre-operative assessment**
Information exchange		**Details**					
E2 – Extract		Ask patient or parents Check medical records – look for red flash on notes					

1.2.5 Check fasting

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval / Selection	**Rule**	**R1 – Fasting not checked**	**Increased risk of aspiration during induction or in theatre**	**3.3; Peri-operative care**	**L**	**H**	**Check that fasting guidelines have been adhered to during the pre-operative visit**
		S2 – Fasting incorrectly taken to be adequate	**Increased risk of aspiration during induction or in theatre**	**3.3; Peri-operative care**	**L**	**H**	
Information exchange		**Details**					
E2 – Extract		Primary source of information is patient / parents. Could also look in the nursing notes.					

1.3 Perform physical examination (where relevant)

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill / Rule**	**C1 – Examination not performed**	**Risk factors not identified**	**3.3; Peri-operative care**	**L**	**H**	**Ensure a thorough history is taken and communicated to the anaesthetist during pre-operative assessments**
Information exchange		**Details**					
N3 – Explore		Depends on the anaesthetic required and the history – examining for the cause of the problem that the patient is telling you about. In the case of chronic illness – what state is the patient in today? Is it the best it can be, or at least adequate for anaesthesia?					

1.4 Decide whether to give premedication

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule**	**S2 – Incorrect choice made**	**Inappropriate medication given or patient anxiety**	**Peri-operative care**	**L**	**L**	**Ensure accurate assessment of patient anxiety during the pre-operative visit**

1.5 Prescribe premedication

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Skill**	**I2 – Incorrect prescription given**	**Wrong medication or dose is given**	**Nurse and pharmacy checks**	**L**	**L**	**Electronic prescribing systems**
Information exchange		**Details**					
E1 – Enter		Prescription chart – name, dose, time. [NB In general, anything given that is of relevance to other carers goes on the prescription chart. However, anything that is not of relevance (e.g. drugs given in theatre that wear off before the patient leaves) is not usually recorded on the prescription chart]					

2.1 to 2.7 Request relevant investigations

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule / Knowledge**	**S1 – Appropriate investigations not requested**	**Risk factors not identified**	**3.3; Peri-operative care**	**M**	**M/H**	**Establish a protocol for deciding on investigations**
Information exchange		**Details**					
E2 – Extract		Ask the patient / parents if they've had any tests. Check clinical notes – tests and results should have been entered by house officer or nurse. If available, check the electronic patient record.					

3.1 Choose anaesthetic drugs

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule / Knowledge**	**S2 – Wrong drugs chosen**	**Drugs cause an adverse reaction**	**3.3; Peri-operative care; Pharmacy checks**	**L**	**L – H (depending on patient risk factors)**	**Ensure a thorough assessment is made of the patient**
Information exchange		**Details**					
N3 – Explore		General principle – the patient will need a hypnotic, an analgesic, a muscle relaxant (maybe), and an anti-emetic (if the patient requests it). Specific drugs chosen on the basis of: - type of operation - patient preference - anaesthetist preference - drug properties - availability					

3.2 Choose delivery method

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule**						
Information exchange		**Details**					
N3 – Explore		Dictated by choice of drug (step 3.1) – e.g. propofol is IV, N_2O and sevofluorane are inhaled. However, as a general principle, choose IV route unless contraindicated due to: - no IV access - patient uncooperative - respiratory risk					

3.3 Decide on post-operative care requirements

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule / Knowledge**	**S2 – Incorrect post-operative care**	**Inappropriate post-operative care given**	**Postoperative care**	**L**	**H**	**Establish a protocol for deciding on post-operative care requirements**
Information exchange		**Details**					
N3 – Explore		Post-operative strategy aims to achieve the following: - local pain block - systemic analgesia - anti-emesis - nursing requirements - disposal (in the ward, ratio of nurse to patients < 1:2; in HDU, ratio is 1:2 and patient is able to breathe unaided; in ICU, ratio is 1:1 and patient is ventilated) Need to take into account the grade of surgery and the nature of the patient					

3.4 Agree choices with patient

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Rule / Knowledge**	**I1 – Patient not consulted**	**Patient dissatisfaction**	**Peri-operative care in induction room**	**L**	**M**	**Nursing check with patient – that anaesthetist has consulted them and they are satisfied**
		I2 – Incorrect information given to patient	**Patient dissatisfaction**	**Consultation with colleagues**	**L**	**M**	
Information exchange		**Details**					
E2 - Extract		Discussion with patient					

4 Reassure patient

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Knowledge**	**I1 / I2 – Patient not reassured**	**Patient anxiety**	**Peri-operative care**	**L**	**M**	**Ensure a pre-operative visit has been conducxted**

5 Invite parents to induction

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Skill**	**I1 – Parents not invited**	**Patient dissatisfaction / anxiety**	**Peri-operative care**	**L**	**M**	**Ensure adherence to hospital policy Nursing check**

3.3 Peri-operative care

As the HTA output for peri-operative care is quite lengthy, an overview is provided initially in Table 3.4, showing the top level tasks and how they map onto successive phases of anaesthesia. The full HTA output is shown in Table 3.5, while the SHERPA and GEMS output is shown in Table 3.6.

Table 3.4: Overview of the HTA for peri-operative care

Task step	**Description**	**Phase**
1	Carry out equipment checks	*Machine check*
2	Prepare drugs	*Induction*
3	Identify patient	
4	Attach essential monitors	
5	Commence patient monitoring	
6	Establish intravenous access	
7	Administer anaesthetic	
8	Secure patient's airway	
9	Cover patient's eyes	
10	Attach additional monitors	
11	Commence additional monitoring	
12	Transfer to operating room	
13	Maintain anaesthesia	*Maintenance*
14	Discontinue anaesthesia	*Emergence*
15	Transfer to recovery room	
16	Complete documentation	

*Table 3.5: Full HTA output for peri-operative care. Task steps marked * have not been analysed further as they were not carried out at the study sites*

0: Provide peri-operative care

Plan 0:

S1 At beginning of list or as required do 1.

S2 For each patient: if anaesthetic is to be administered intravenously then do in order 2 to 16. If anaesthetic is to be administered by other means then carry out step 6 after step 8. If induction room is not being used then omit steps 11 and 12.

1. Carry out equipment checks

Plan 1:

S4 At the beginning of the list do in any order 1.1 to 1.12. Before each patient do 1.11 and 1.12

1.1 Confirm that anaesthetic machine is connected to electricity supply

1.2 Switch anaesthetic machine on

1.3 Ensure anaesthetic machine is serviceable

Plan 1.3:

S4 if information available do in any order 1.3.1 and 1.3.2. If serviceability cannot be confirmed then consult technician

1.3.1 Inspect labelling on machine

1.3.2 Inspect service logbook*

1.3.3 Examine machine status report*

1.4 Ensure oxygen analyser is present

Plan 1.4:

S4 Do in any order 1.4.1 and 1.4.2.

S2 If calibration necessary do 1.4.3. If calibration not necessary then continue

1.4.1 Switch analyser on*

1.4.2 Position oxygen sensor to monitor common gas outlet*

1.4.3 Calibrate analyser*

1.5 Check the supply of medical gases

Plan 1.5:

S4 For each gas do 1.5.1.

S4 For each pipeline do 1.5.2, 1.5.3, 1.5.4 and 1.5.5.

S4 For oxygen do 1.5.6.

S4 For each empty cylinder do 1.5.7.

1.5.1 Check the amount of gas available*

1.5.2 Identify the gas being supplied*

1.5.3 Check gas monitor

1.5.4 Confirm that the pipeline is correctly inserted into the supply terminal

1.5.5 Check the pressure gauge

1.5.6 Confirm that a reserve supply is available

1.5.7 Confirm that a blanking plug is fitted

1.6 Check the operation of flowmeters

Plan 1.6:

S3 For each flowmeter do 1.6.1.

S4 For oxygen do 1.6.2.

1.6.1 Confirm that the bobbin moves smoothly and freely throughout its range

1.6.2 Confirm correct operation of the emergency bypass

1.7 Check the vaporisers

Plan 1.7:

S4 For each vaporiser do in order 1.7.1 to 1.7.4.

S2 If vaporiser is not serviceable then replace vaporiser and repeat the checks. If all vaporisers are serviceable then continue.

1.7.1 Confirm that the vaporiser is filled to the correct level

1.7.2 Confirm that the vaporiser is correctly seated

1.7.3 Check vaporiser for leaks

Plan 1.7.3:

S4 With vaporiser on and off do in order 1.7.3.1 to 1.7.3.2

1.7.3.1 Occlude the common gas outlet

1.7.3.2 Observe the pipe for leaks

1.7.4 Turn vaporiser off

1.8 Check the breathing system

Plan 1.8:

S1 Do in order 1.8.1 to 1.8.4

1.8.1 Inspect the system for correct configuration

1.8.2 Ensure all connections are secure

1.8.3 Perform a pressure leak test

Plan 1.8.3:

S1 Do in order 1.8.3.1 to 1.8.3.3

1.8.3.1 Occlude the patient port

1.8.3.2 Compress the reservoir bag

1.8.3.3 Observe the system for leaks

1.8.4 Ensure correct operation of unidirectional valves

1.9 Check the ventilator

Plan 1.9:

S1 Do in order 1.9.1 to 1.9.7

1.9.1 Confirm correct configuration of the ventilator tubing

1.9.2 Confirm secure attachment of tubing

1.9.3 Select mode of operation

1.9.4 Confirm that adequate pressure is generated during inspiration

1.9.5 Confirm correct functioning of the pressure relief valve

1.9.6 Confirm correct functioning of the disconnect alarm

1.9.7 Confirm availability of an alternative means of ventilation

1.10 Check the scavenging system

Plan 1.10:

S1 Do in order 1.10.1 to 1.10.3

1.10.1 Switch the system on

1.10.2 Confirm correct functioning of the system

1.10.3 Confirm tubing is attached to the expiratory port of ventilator or breathing system

1.11 Check ancillary system

Plan 1.11:

S4 Do in any order 1.11.1 to 1.11.3

1.11.1 Confirm availability of airway management equipment

1.11.2 Confirm correct functioning of suction apparatus

1.11.3 Confirm patient can be tilted head-down

1.12 Check patient monitoring equipment

Plan 1.12:

S1 For each item do in order 1.12.1 to 1.12.2.

S4 For each item as necessary choose any of 1.12.3, 1.12.4 and 1.12.5

1.12.1 Switch on item

1.12.2 Check functionality of monitor

1.12.3 Set default alarm limit

1.12.5 Place in stand-by mode

2. Prepare drugs

Plan 2:

S1 For each drug do in order 2.1 to 2.4

2.1 Collect drug

2.2 Determine the amount of drug required

2.3 Transfer required amount to syringe

2.4 Label syringe

3. Identify patient

Plan 3:

S3 After patient has arrived in anaesthetic room do at the same time 3.1 and 3.2. If patient identity and type of operation confirmed then continue. If not confirmed then consult surgeon.

3.1 Check patient identification against case notes

3.2 Confirm the type of operation that the patient is expecting to be performed

4. Attach essential non-invasive monitors

Plan 4:

S1 Do 4.1

S4 As required do in any order 4.2, 4.3 and 4.4

4.1 Attach pulse oximeter

4.2 Attach blood pressure monitor

4.3 Attach ECG monitor

4.4 Attach gas / agent monitor[6]

5. Commence patient monitoring

Plan 5:

S4 Continuously do in any order 5.1 to 5.4.

5.1 Monitor oxygen saturation

5.2 Monitor blood pressure

5.3 Monitor heart rate and rhythm

5.4 Monitor respiration and respiratory gas traces

6. Establish intravenous access

Plan 6:

S1 Do in order 6.1 to 6.2.

S2 If fluid required at this point do 6.3. If fluid not required at this point then continue

6.1 Clean skin at cannulation site

6.2 Insert cannula

6.3 Commence IV fluid administration

Plan 6.3:

S1 Do in order 6.3.1 to 6.3.4. If unable to administer IV fluid then repeat from 6.3.1. If able to administer fluid then continue.

6.3.1 Connect IV

6.3.2 Check IV flow switches

6.3.3 Set infusion rate

6.3.4 Start infusion device

7. Administer anaesthetic

Plan 7:

S1 Throughout do 7.1.

S1 Do 7.2.

S4 When oxygen saturation is sufficient then do in any order 7.3, 7.4 and 7.5.

S2 When patient is unresponsive do 7.6 as required.

S1 Following administration do 7.7.

S2 If necessary do 7.8.

[6] This includes capnography

7.1 Monitor patient's level of responsiveness

7.2 Administer oxygen at 100% concentration

7.3 Administer hypnotic drug

7.4 Administer inhalation agent

7.5 Administer analgesic drug

7.6 Administer muscle relaxant drug

7.7 Monitor inhalation agent

Plan 7.7:

S4 Do in any order 7.7.1 and 7.7.2.

7.7.1 Monitor inspired inhalation agent concentration

7.7.2 Monitor ratio between oxygen and N_2O

7.8 Adjust anaesthetic concentration

8. Secure patient's airway

Plan 8:

S1 Do 8.1.

S4 When oxygen saturation is sufficient then do any of 8.2 to 8.4.

S4 As required do 8.5.

S1 Do 8.6.

8.1 Administer oxygen at 100% concentration

8.2 Insert oral airway

8.3 Insert laryngeal mask airway

8.4 Insert tracheal tube

8.5 Insert throat pack

8.6 Fix airway

9. Cover patient's eyes

10. Attach additional monitors

Plan 10:

S4 Do in any order 10.1 to 10.4 as required.

10.1 Attach temperature probe

10.2 Attach central venous pressure monitor

10.3 Attach urinary output monitor

10.4 Attach peripheral nerve stimulator

11. Commence additional patient and anaesthetic monitoring

Plan 11:

S4 Continuously do in any order 11.1 to 11.4 as required

11.1 Monitor temperature of patient

11.2 Monitor central venous pressure

11.3 Monitor urinary output

11.4 Monitor degree of neuromuscular block

12. Transfer patient to operating room

Plan 12:

S2 If intravenous infusion in use do in order 12.1 to 12.8. If IV not in use do in order 12.3 to 12.8.

S4 As required do 12.9.

S2 When satisfied that operation can commence do 12.10.

12.1 Switch off IV infusion

12.2 Remove IV infusion set from induction room infusion device

12.3 Disconnect monitoring lines from induction room monitors

Plan 12.3: As required do in any order 12.3.1 to 12.3.8. Do 12.3.9.

12.3.1 Disconnect pulse oximeter

12.3.2 Disconnect temperature probe

12.3.3 Disconnect blood pressure monitor

12.3.4 Disconnect ECG monitor

12.3.5 Disconnect gas analyser

12.3.6 Disconnect capnograph

12.3.7 Disconnect central venous pressure monitor

12.3.8 Disconnect pulmonary arterial pressure monitor

12.3.9 Put monitors in standby mode

12.4 Confirm lines on patient are secure

12.5 Confirm patient is secure on trolley

12.6 Move trolley into theatre

12.7 Move patient from trolley to operating table

Plan 12.7:

S1 Do in order 12.7.1 to 12.7.5.

S2 If patient can be moved without movement device then omit 12.7.2 and 12.7.4.

12.7.1 Secure table and trolley

12.7.2 Insert movement device between trolley and table

12.7.3 Move patient

12.7.4 Remove movement device

12.7.5 Remove trolley

12.8 Connect monitoring lines to operating theatre monitors

Plan 12.8:

S1 Do 12.8.1.

S4 As required do in any order 12.8.2 to 12.8.7.

12.8.1 Connect pulse oximeter

12.8.2 Connect blood pressure monitor

12.8.3 Connect ECG monitor

12.8.4 Connect gas analyser

12.8.5 Connect temperature probe

12.8.6 Connect central venous pressure monitor

12.8.7 Connect urinary output monitor

12.9 Recommence IV infusion

Plan 12.9:

S1 Do in order 12.9.1 to 12.9.2

12.9.1 Set up theatre infusion set

12.9.2 Start fluid administration

12.10 Instruct surgical team to commence surgery

13. Maintain anaesthesia

Plan 13:

S2 If step 12 omitted, then do 12.10 when satisfied that operation can commence.

S1 Continuously do 13.1.

S2 According to observations from 13.1 do in any order 13.2.

S1 As end of operation approaches do 13.3 and 13.4.

13.1 Monitor condition

Plan 13.1:

S4 Do continuously in any order 13.1.1 to 13.1.8.

S1 Every five minutes do 13.1.9.

13.1.1 Monitor patient's level of responsiveness

13.1.2 Monitor anaesthetic administration

Plan 13.1.2:

S4 Do in any order 13.1.2.1 and 13.1.2.2.

13.1.2.1 Monitor inspired inhalation agent concentration

13.1.2.2 Monitor inspired O_2 concentration

13.1.3 Monitor oxygen saturation

13.1.4 Monitor blood pressure

13.1.5 Monitor heart rate and rhythm

13.1.6 Monitor respiration and respiratory gas traces

13.1.7 Monitor temperature of patient

13.1.8 Monitor surgical activity

Plan 13.1.8:

S4 As required do in any order 13.1.8.1 and 13.1.8.2

13.1.8.1 Monitor blood loss

Plan 13.1.8.1:

S4 Do in any order 13.1.8.1.1 to 13.1.8.1.4

13.1.8.1.1 Inspect swabs for blood

13.1.8.1.2 Inspect suction machine for blood

13.1.8.1.3 Inspect wound on patient

13.1.8.1.4 Listen for blood 'sucking' noises

13.1.8.2 Monitor urine output

13.1.9 Record observations on observation chart

13.2 Adjust anaesthetic concentration

13.3 Review post-operative care requirements

13.4 Inform recovery nurse of post-operative analgesia requirements

14. Discontinue anaesthesia

Plan 14:

S1 Do 14.1 throughout.

S1 Do 14.2.

S2 If neuromuscular T_1 < 75% of T_0 then do 14.3. If T_1 not < 75% of T_0 then omit 14.3

S1 When patient is responsive do 14.4.

S1 When oxygen saturation is sufficient, do 14.5.

14.1 Monitor patient's level of responsiveness

14.2 Discontinue drug administration

14.3 Administer drugs to reverse residual neuromuscular blockade

14.4 Administer oxygen at 100% concentration

14.5 Remove artificial airway

Plan 14.5:

S2 If throat pack in use then do 14.5.1.

S4 Do 14.5.2 to 14.5.5.

S1 When patient is able to breathe unaided do 14.5.6.

14.5.1 Remove throat pack

14.5.2 Unfix artificial airway

14.5.3 Apply suction to trachea

14.5.4 Place patient in left lateral position

14.5.5 Uncover patient's eyes

14.5.6 Remove artificial airway

15. Transfer to recovery room

Plan 15:

S1 Do in order 15.1 to 15.7

15.1 Continue oxygen administration

15.2 Discontinue intravenous fluid administration

15.3 Disconnect monitors

Plan 15.3:

S4 As required do in any order 15.3.1 to 15.3.9

15.3.1 Disconnect pulse oximeter

15.3.2 Disconnect temperature probe

15.3.3 Disconnect blood pressure monitor

15.3.4 Disconnect ECG monitor

15.3.5 Disconnect gas analyser

15.3.6 Disconnect capnograph

15.3.7 Disconnect central venous pressure monitor

15.3.8 Disconnect pulmonary arterial pressure monitor

15.3.9 Disconnect urinary output monitor

15.4 Move patient from operating table onto trolley

Plan 15.4:

S1 Do in order 15.4.1 to 15.4.5.

S2 If patient can be moved without movement device then omit 15.4.3 and 15.4.5.

15.4.1 Retrieve trolley

15.4.2 Secure table and trolley

15.4.3 Insert movement device between trolley and table

15.4.4 Move patient

15.4.5 Remove movement device

15.5 Place patient in left lateral position

15.6 Move trolley into recovery room

15.7 Hand over to recovery nurse

Plan 15.7:

S3 Do 15.7.1 and 15.7.2.

S2 If fluid therapy required then do 15.7.3.

S1 Until satisfied that the patient can be left in the care of the recovery nurse do 15.7.4.

15.7.1 Connect monitoring lines to recovery room monitor

Plan 15.7.1

S1 Do 15.7.1.1

S4 As required do 15.7.1.2 and 15.7.1.3.

15.7.1.1 Connect pulse oximeter

15.7.1.2 Connect blood pressure monitor

15.7.1.3 Connect ECG

15.7.2 Inform recovery nurse of post-operative care

requirements

15.7.3 Restart IV infusion

15.7.4 Monitor vital signs

16. Complete documentation

Plan 16:

S4 Do in any order 16.1 and 16.2

S1 Do 16.3

16.1 Check details on anaesthetic chart

16.2 Check post-operative care instructions

16.3 File documentation

1.1 Confirm that anaesthetic machine is connected to electricity supply

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**						

1.2 Switch anaesthetic machine on

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**						
Information exchange		**Details**					
A1 – Activate		Machine states during activation will be machine specific, but are likely to include: - self-calibration - test gases					

1.3.1 Inspect labelling on machine

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Skill**	**R1 – Label not identified**	**Use of a defective machine**	**Malfunction detected during peri-operative care**	**L**	**H**	**Ensure compliance with checklist**
		R2 – Label misread	**Use of a defective machine**	**Malfunction detected during peri-operative care**	**L**	**H**	**Ensure preventative maintenance schedule is followed**
Information exchange		**Details**					
E2 – Extract		Two types of label: - specified by ISO standards - specified by local standards (maintenance information) Machine-specific, but needs to be visible. Co-located with the device / control with which it's related					

1.5.3 Check gas monitor (gas, O_2 and volatile agent)

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Gas monitor not checked**	**Incorrect gas mixture administered**	**Immediate?**	**L**	**H**	**Ensure compliance with checklist** **Automate this task step**
Information exchange		**Details**					
E2 – Extract		The location is machine-specific, and may be self-checked. See machine user manual or FRCA checklist for more details.					

1.5.4 Ensure that the pipeline is correctly inserted into the supply terminal

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Pipeline not checked**	**Gas not supplied during anaesthesia**	**Anaesthetic machine alarms**	**L**	**H**	**Ensure compliance with checklist Automate this task step**
		C3 – Wrong pipeline checked	**Wrong gas supplied during anaesthesia**	**Anaesthetic machine alarms**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

Information exchange	Details
E2 – Extract	Value obtained from visual inspection and tug test

1.5.5 Check the pressure gauge

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Pressure gauge not checked**	**Gas not supplied during anaesthesia**	**Anaesthetic machine alarms**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

Information exchange	Details
E2 – Extract / M2 – Monitor	Target value for individual cylinders depends on state of cylinder and the saturated vapour pressure for individual gases, but 400kPa (4ATM) is the machine stepdown pressure for pipelines. Indicated using pipeline pressure gauges – location and format depends on the machine

1.5.6 Ensure that a reserve supply of O_2 is available

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Reserve supply not checked**	**Reserve supply unavailable if needed**	**Immediate**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

1.5.7 Ensure that a blanking plug is fitted to cylinder yoke

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action / Check	**Skill**	**A8 / C1 – Blanking plug not fitted or checked**	**Gas leak in system**	**Leak detected by anaesthetist Machine alarms**	**L**	**H**	**Ensure compliance with checklist**

Information exchange	Details
E2 – Extract	Blanking plug is to be found on cylinder yoke when not in use

1.6.1 Ensure that the flowmeter bobbin moves smoothly and freely throughout its range

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Bobbin not checked**	**Gas not supplied during anaesthesia Hypoxia**	**Gas monitor alarms SaO_2 alarms**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

Information exchange	Details
A1 – Activate / E2 – Extract	Flowmeter modes: Off, Low > High. Need to check that the valve doesn't stick at one end of the scale. The rate of change is machine specific.

1.6.2 Ensure correct operation of the emergency bypass

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Emergency bypass not checked**	**Oxygen unavailable in an emergency**	**None**	**L**	**H**	**Ensure compliance with checklist Automate this task step**
		C4 – Incorrect operation not identified	**Oxygen unavailable in an emergency**	**None**	**L**	**H**	

Information exchange	Details
A1 – Activate / E2 – Extract	Emergency bypass modes: Off, On

1.7.1 Ensure that the vaporiser is filled to the correct level

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Vaporiser not checked**	**Vapour not supplied during anaesthesia** **Patient awareness**	**Gas monitor alarms**	**L**	**M-H**	**Ensure compliance with checklist Automate this task step**
		C4 – Vaporiser filled to incorrect level	**Vapour not supplied during anaesthesia** **Patient awareness**	**Gas monitor alarms**	**L**	**M-H**	

Information exchange	Details
E2 – Extract / M2 – Monitor	Level checked by visual inspection. Target level – sufficient for the operation / list

1.7.2 Ensure that the vaporiser is correctly seated

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Vaporiser position not checked**	**Machine leaks** **Patient not ventilated**	**Leak detected by anaesthetist** **Low pressure alarm**	**L**	**H**	**Ensure compliance with checklist** **Automate this task step**

Information exchange	Details
E2 – Extract	Seating identified through visual inspection of the connection between vaporiser and machine. May be checked automatically by the machine

1.7.3.1 Occlude the common gas outlet

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Outlet not occluded**	**Gas not supplied during anaesthesia** **Patient not ventilated**	**Leak detected by anaesthetist** **Low pressure alarm**	**L**	**H**	

1.7.3.2 Observe the pipe for leaks

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Pipe not checked**	**Gas not supplied during anaesthesia** **Pollution of induction room**	**Leak detected by anaesthetist** **Low pressure alarm**	**L**	**H**	**Ensure compliance with checklist**

Information exchange	Details
E2 – Extract	Listen for escaping gas, observe the pipe / backbar for holes. Can also use soapy water and check for bubbles. May be checked automatically by the machine

1.7.4 Turn vaporiser off after checking

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Vaporiser not turned off**	**Wastage of gas** **Pollution of induction room**	**Leak detected by operator**	**L**	**L**	**Ensure indicator of status is clearly visible** **Use a forcing function where possible** **Ensure compliance with checklist**

Information exchange	Details
A3 – Deactivate	Vaporiser modes: High > Low, Off

1.8.1 Inspect the breathing system for correct configuration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C1 – Check not made**	**Breathing system ineffective during anaesthesia**	**1.8.2; Leak detected by operator**	**L**	**H**	**Ensure compliance with checklist**
		C4 – Incorrect configuration not identified	**Breathing system ineffective during anaesthesia**	**1.8.2; Leak detected by operator**	**L**	**H**	

Information exchange	Details
E2 – Extract	Visual inspection. Based on anaesthetist's knowledge about different types of breathing system (e.g. Mapleson A, Mapleson D, Open)

1.8.2 Ensure all connections are secure[7]

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Connections not checked**	**Gas not supplied during anaesthesia** **Pollution of induction room**	**Disconnection or leak detected by operator**	**L**	**H**	**Ensure compliance with checklist**
		C4 – Insecure connections not identified	**Gas not supplied during anaesthesia** **Pollution of induction room**	**Disconnection or leak detected by operator**	**L**	**H**	

Information exchange	Details
E2 – Extract	Visual inspection and tug test

1.8.3.1 Occlude the patient port on the breathing system

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A6 – Wrong port occluded**	**Breathing system ineffective during anaesthesia**	**Malfunction detected by operator**	**L**	**H**	**Ensure compliance with checklist**
		A8 – Patient port not occluded	**Breathing system ineffective during anaesthesia**	**Malfunction detected by operator**	**L**	**H**	

[7] Task step 1.8.2: where there is no separate induction room (for example in US and EUR), C1 and C4 would be identified sooner as the same ventilator would be in use throughout the case

1.8.3.2 Compress the reservoir bag

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Bag not compressed**	**Breathing system ineffective during anaesthesia**	**Malfunction detected by operator**	**L**	**H**	**Ensure compliance with checklist**

1.8.3.3 Observe the breathing system for leaks

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Leaks not identified**	**Breathing system ineffective during anaesthesia**	**Disconnection or leak detected by operator**	**L**	**H**	**Ensure compliance with checklist**

Information exchange	Details
E2 – Extract	Listen for air, observe for holes, check that the bag doesn't deflate when compressed with the patient port occluded

1.8.4 Ensure correct operation of unidirectional valves

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 / C2 – Valves not checked**	**Breathing system ineffective during anaesthesia**	**In theatre: high CO_2 reading, low SpO_2 reading**	**L**	**H**	**Ensure compliance with checklist**

Information exchange	Details
A1 – Activate / E2 – Extract	Pressurise them and check that they go up to their limit. See also AAGBI guidelines

1.9.1 Confirm correct configuration of the ventilator tubing[8]

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C1 / C2 – Tubing not checked**	**Ventilator ineffective during anaesthesia**	**Peri-operative care**	**L**	**H**	**Ensure compliance with checklist**
		C4 – Incorrect configuration not identified	**Ventilator ineffective during anaesthesia**	**Peri-operative care**	**L**	**H**	**Ensure planned maintenance schedule is complied with** **Train operators on the machines that are being used** **Standardisation of machines**
Information exchange		**Details**					
E2 – Extract		Visual inspection. Correct configuration depends on the type of machine					

1.9.2 Confirm the tubing is securely attached

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 / C2 – Tubing not checked**	**Ventilator ineffective during anaesthesia**	**Peri-operative care**	**L**	**H**	**Ensure compliance with checklist**
		C4 – Tubing not checked properly	**Ventilator ineffective during anaesthesia**	**Peri-operative care**	**L**	**H**	
Information exchange		**Details**					
E2 – Extract		Visual inspection and tug test					

[8] Machine checks are carried out by ODA. Breathing system checks are carried out by anaesthetist (and/or ODA).

1.9.3 Select mode of operation

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A7 – Controls incorrectly set**	**Ventilator ineffective during anaesthesia**	**Peri-operative care**	**M-H**	**H**	**Machine design – eliminate the common gas outlet control (adults only) or make the switch setting more clearly visible. A better solution is to discourage the use of multi-modal machines**

Information exchange	Details
A2 – Adjust	General states: circle mode and open mode. There may be additional machine-specific states (e.g. ventilation, spontaneous, pressure control, volume control, IMV, SIMV, off)

1.9.4 Confirm that adequate pressure is generated during inspiration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Rule**	**A7 – Inadequate pressure level set**	**Ventilator ineffective during anaesthesia**	**Peri-operative care**	**L**	**H**	**Use of ventilation monitors (e.g. capnograph, ventilation monitors) to trap this error.**

Information exchange	Details
A2 – Adjust / E2 – Extract	Use a dummy lung. Dial up a pressure and check that it's enough to make the lung move

1.9.5 Confirm functioning of the pressure relief valve

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Valve not checked**	**Risk of damage to machine Valve occluded Barotrauma to patient**	**None**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

Information exchange	Details
A1 – Activate / E2 – Extract	States of activation: open, closed. If it's an internal valve, check that it operates during occlusion

1.9.6 Confirm correct functioning of the disconnect alarm

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Alarm not checked**	**Unable to detect failure of the ventilator**	**None**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

Information exchange	Details
A1 – Activate / E2 – Extract	States of activation – on, off. Should trigger when disconnected from dummy lung. Set the minimum pressure, and see whether the alarm is triggered if that pressure is not reached

1.9.7 Confirm availability of an alternative means of ventilation

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Availability not checked**	**Unable to ventilate patient if ventilator fails**	**Peri-operative care**	**L**	**H**	**Ensure compliance with checklist Automate this task step**

Information exchange	Details
E2 – Extract	Look for presence of Ambu-bag, T-piece or other alternative device

1.10.1 Switch the scavenging system on

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – System not switched on**	**Scavenging system not available**	**Immediate**	**L**	**L**	**Ensure compliance with checklist**
Information exchange		**Details**					
A1 – Activate		States of activation – off, on. State shown using a visual indicator. It's usually left on, so operator just needs to connect tube					

1.10.2 Confirm correct functioning of the scavenging system

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – System functioning not checked**	**Scavenging system not available**	**Smell volatile agent during peri-operative care?**	**L**	**L**	**Ensure compliance with checklist Automate this task step**
Information exchange		**Details**					
E2 – Extract		Visual indicator at top of tube – e.g. check that marker is between two lines					

1.10.3 Confirm scavenging tubing is attached to the expiratory port of ventilator or breathing system

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Attachment not checked**	**Scavenging system not available**	**Smell volatile agent during peri-operative care?**	**L**	**L**	**Ensure compliance with checklist**
Information exchange		**Details**					
E2 – Extract		Visual check and tug test					

1.11.1 Confirm availability of airway management equipment

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Availability not checked**	**Airway management equipment not available**	**Peri-operative care**	**L**	**H**	**Ensure compliance with checklist**
Information exchange		**Details**					
E2 – Extract		Intubation tray or workspace on anaesthetic machine (“side”)					

1.11.2 Confirm correct functioning of suction apparatus[9]

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Functioning not checked**	**Suction not available** **Risk of cross-infection between cases**	**When suction equipment is required**	**L (at start of list), H (between cases)**	**H**	**Ensure compliance with checklist**
Information exchange		**Details**					
E2 – Extract		Listen for air intake and feel for suction against hand. See also AAGBI guidelines					

1.11.3 Confirm trolley can be tilted head-down

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Tilt not checked**	**Difficulty in managing patient during an emergency**	**Peri-operative care**	**M**	**H**	**Nurse / ODA to check**
Information exchange		**Details**					
E2 – Extract		Operate the tilt lever at the side or end of the trolley					

[9] Task 1.11.2: Check more likely to be made for emergency / full stomach cases

1.12.1 Switch on monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Item not switched on**	**Unable to check item functioning**	**Immediate**	**L**	**M**	**Ensure compliance with checklist**
Information exchange		**Details**					
A1 – Activate		Monitor states: On, Off					

1.12.2 Check functionality of monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Functionality not checked**	**Monitor doesn't work correctly**	**5.1 – 5.4; 11.1-11.5 13.1**	**L**	**H**	**Ensure compliance with checklist Automate this task step**
Information exchange		**Details**					
E2 – Extract		Depends on type of monitor – some are self-calibrating. Gas values should be appropriate for air if disconnected from pipelines (e.g. 21% oxygen). ECG – should show flatline. If wire is shaken then should see activity. If no display then not working					

1.12.3 Set default alarm limit

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Rule**	**A7 – Inappropriate alarm limit set**	**Alarm sounds inappropriately or does not sound**	**Peri-operative care Alternative indicator (e.g. heart rate alarm if SpO_2 alarm is not triggered)**	**L**	**M**	**Automatic alarm limit setting system (which is statistically robust)**
Information exchange		**Details**					
A2 – Adjust		Turn a knob or select options via the monitor display. Limit shown on display					

1.12.4 Put monitors in standby mode

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Item not set in standby mode**	**Alarm sounds inappropriately**	**Immediate**	**H**	**L**	**Use of a context-sensitive alarm that detects when the machine is not being used**
Information exchange		**Details**					
A3 – Deactivate		Depends on type of monitor – however, there must be some form of indicator (e.g. bed symbol)					

2.1 Collect drug

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A6 – Wrong drug collected**	**Drug is ineffective or causes an adverse reaction**	**None**	**L**	**H**	**Cross-check the label and ampoule** **Drug detector between syringe and cannula** **Barcode check of drug packaging**
Information exchange		**Details**					
N1 – Locate		Worktop of the anaesthetic machine (“side”) – should have been put out by the ODP. Specific drugs identified by labels					

2.2 Determine the amount of drug required

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule**	**S2 – Wrong amount selected**	**Insufficient dose or overdose**	**None**	**L**	**M-H**	**Make a pre-programmed calculator available in the induction room to calculate doses. Could also distribute PDA software for the same purpose.**
Information exchange		**Details**					
E2 – Extract		Patient’s weight used to calculate the per kilogram dose					

2.3 Transfer required amount to syringe

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A4 – Wrong amount transferred**	**Insufficient dose or overdose**	**None**	**L**	**M-H**	**Cross-check the dose** **Pre-loaded syringe**

2.4 Label syringe

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A7 – Wrong label applied**	**Drug is misidentified**	**Check before administration**	**L**	**H**	**Cross-check the label** **Standardise labelling system**
		A8 – Label not applied	**Drug is misidentified**	**None**	**L**	**H**	**Ensure the label is put on immediately**
Information exchange		**Details**					
E1 – Enter		Name, dilution					

3.1 Check patient identification against case notes

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval / Communication	**Skill**	**R1 / I1 – Identification not checked**	**Incorrect anaesthetic plan executed**	**If adverse effect of treatment is noticed**	**L**	**H**	**Assistant to perform the check** **Use of the patient pathway / pre-operative checklist**
		R2 / I2 – Patient misidentified	**Incorrect anaesthetic plan executed**	**None**	**L**	**H**	
Information exchange		**Details**					
E2 – Extract		Information needed: patient's name and type of operation to compare against patient's answers. Nursing info – fasting time, consent, allergies, loose teeth					

3.2 Confirm the type of operation that the patient is expecting to be performed

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval / Communication	**Skill**	**R1 / I1 – Type of operation not checked**	**Incorrect anaesthetic plan executed**	**Surgeon check**	**L**	**M-H**	**Ensure that the pre-operative checklist is used**
		R2 / I2 – Type of operation misidentified	**Incorrect anaesthetic plan executed**	**Surgeon check**	**L**	**M-H**	**Ensure correct information is provided on operating lists**
Information exchange		**Details**					
E2 – Extract		As for 3.1					

4.1 Attach pulse oximeter

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – Oximeter not attached**	**No reading of pulse and SpO_2**	**5.1 Monitor oxygen saturation**	**L**	**H**	**Ensure compliance with guidelines** **Cross-check that oximeter is attached**
		A5 – Oximeter not correctly positioned	**Incorrect reading / recording of pulse and SpO_2**				**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

4.2 Attach blood pressure monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – BP monitor not attached**	**No reading of BP**	**5.2 Monitor blood pressure**	**L**	**H**	**Ensure compliance with guidelines** **Cross-check that BP monitor is applied**
		A5 – BP monitor not correctly positioned	**Incorrect reading of BP**		**L-M**	**H**	**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

4.3 Attach ECG monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – ECG monitor not attached**	**No reading of ECG**	**5.3 Monitor heart rate and rhythm**	**L**	**H**	**Ensure compliance with guidelines** **Cross-check that ECG monitor is applied**
		A5 – ECG monitor not correctly positioned	**Incorrect reading of ECG**		**M**	**H**	**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

4.4 Attach gas / agent monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not attached**	**Inadequate monitoring of inhaled and exhaled gases**	**5.4**	**L**	**H**	**Ensure compliance with guidelines** **Cross-check that monitor is applied**

5.1 Monitor oxygen saturation

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – SpO_2 not monitored**	**Hypoxia**	**Alarm**	**L**	**H**	**Context-specific monitoring/alarms that take into account what the anaesthetist is doing at the time** **Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
Information exchange		**Details**					
M1 – Monitor		Data found on display ("SaO_2"). Normal parameters: > 95%					

5.2 Monitor blood pressure

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – BP not monitored**	**Hypotension or hypertension**	**Alarm**	**L**	**M-H**	**Context-specific monitoring/alarms that take into account what the anaesthetist is doing at the time** **Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
		R2 – BP misread	**Hypotension or hypertension**	**Alarm**	**L**	**M-H**	
Information exchange		**Details**					
M1 – Monitor		Data found on display. Normal parameters: 120/80 for a 70kg person or mean arterial pressure of 50mmHg					

5.3 Monitor heart rate and rhythm

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Not monitored**	**Arrythmia, tachycardia or bradycardia missed**	**Alarm**	**L**	**H**	**Context-specific monitoring/alarms that take into account what the anaesthetist is doing at the time** **Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
		R2 – Misread	**Arrythmia, tachycardia or bradycardia missed**	**Alarm**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		Data found on display. Normal parameters: 60-80 BPM for adults (mean 72), 100 BPM for children, sinus rhythm					

5.4 Monitor respiration & respiratory gas traces

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Respiratory rate not monitored**	**Failure to identify:** • **Respiratory rate too high or too low** • **Hypoxia, hypocarbia or hypercarbia**	**Alarm**	**L**	**H**	**Context-specific monitoring/alarms that take into account what the anaesthetist is doing at the time** **Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
		R2 – Respiratory rate misread	**Failure to identify:** • **Respiratory rate too high or too low** • **Hypoxia, hypocarbia or hypercarbia**	**Alarm**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		Data on display. Normal parameters: End-tidal CO_2 ($ETCO_2$ on display) approximately 5.4kPa (needs to be detected after anaesthetic). Agent concentration depends on agent.					

6.1 Clean skin at cannulation site

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Skin not cleaned**	**Infection risk**	**None**	**H**	**L - H**	**Ensure aseptic technique is applied – this could be done by the assistant**

6.2 Insert cannula

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Cannula inserted incorrectly**	**Swelling of limb**	**Pressure alarm on infusion device**	**L-M**	**M**	**Ultrasound guidance** **Ensure regular practice at cannulation**
		A8 – Cannula not inserted	**Unable to give IV fluids**	**Immediate**	**L**	**M-H**	**Establish a protocol for using cannulas**

6.3.1 Connect IV

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A9 – IV connected incorrectly**	**IV fluids / medication not administered**	**Infusion set alarms (if automatic device being used)**	**H**	**L**	**Assistant to check functionality of IV equipment**

6.3.2 Check IV flow switches

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Not checked**	**IV fluids / medication not administered**	**Infusion set alarms (if automatic device being used)**	**H**	**L**	**Assistant to check functionality of IV equipment**
Information exchange		**Details**					
A2 – Adjust / E2 – Extract		States: On, Off. Should be on					

6.3.3 Set infusion rate

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Rule**	**A7 – Wrong infusion rate set**	**Too much or too little fluid**	**Check by anaesthetist or assistant**	**L**	**L-H**	**Compulsory use of electronic flow control devices (NB already compulsory in paediatrics)**
Information exchange		**Details**					
A2 – Adjust		1 – 3 times the maintenance rate, to allow for: - duration of fasting - maintenance fluid - interoperative losses (Bolus dosing)					

6.3.4 Start infusion device

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Device not started**	**No infusion Dehydration No compensation of fluid volume Hypotension**	**Check by anaesthetist or assistant**	**L**	**L-H**	**Cross-check of machine**
Information exchange		**Details**					
A1 – Activate		States: Off, Low > High					

7.1 Monitor patient's level of responsiveness

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Level of responsiveness not assessed**	**Patient may be too light**	**Immediate**	**L**	**H**	**Ensure use of monitors (e.g. BP, HR, end-tidal volume)**
		R2 – Level of responsiveness incorrectly assessed	**Patient may be too light**	**Immediate**	**L**	**H**	**Context-specific monitoring / alarms**
Information exchange		**Details**					
M2 – Monitor		Patient becomes unconscious, indicated by e.g. loss of eyelash reflex; U on AVPU scale					

7.2 Administer oxygen at 100% concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A4 – Wrong amount of oxygen supplied**	**Hypoxia**	**Immediate**	**L**	**H**	**Cross-check that oxygen is supplied**
		A8 – Oxygen not supplied					
Information exchange		**Details**					
A1 – Activate		States: Off, Low > High [6-8 l/ min for 100% concentration]					

7.3 Administer hypnotic drug

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A4 – Wrong amount administered**	**Patient is too light (awareness) or too deep (low BP)**	**Immediate**	**L**	**L-H**	**Ensure clinical signs are monitored during administration** **Context-specific monitoring / alarms**
Information exchange		**Details**					
A1 – Activate		States: Inactive, Active					

7.4 Administer inhalation agent

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A4 – Wrong amount administered**	**Patient is too light (awareness) or too deep (low BP)**	**Immediate**	**L**	**L-H**	**Ensure clinical signs are monitored during administration**
		A8 – Not administered	**Patient awareness**	**7.7.1 Monitor inspired inhalation concentration**	**L**	**H**	**Monitoring of end-tidal agent** **Depth of anaesthesia monitor** **Context-specific monitoring / alarms**
Information exchange		**Details**					
A1 – Activate		States: Off, Low > High					

7.5 Administer analgesic drug

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – Drug / agent not administered**	**No drug given** **Patient could react to painful stimulus**	**Clinical observation (e.g. tachycardia)**	**L**	**L-H**	**Cross-check that analgesic is given at the correct dose** **Context-specific monitoring/alarms**
		A4 – Wrong amount administered	**Inadequate pain relief or overdose**	**Clinical observation**	**L**	**M**	
Information exchange		**Details**					
A1 – Activate		States: Inactive, Continuous infusion, Bolus injection					

7.6 Administer muscle relaxant drug

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – Drug / agent not administered**	**Drug is ineffective**	**Clinical observation and n-m transmission monitor (if used)**	**L**	**M**	**Use of neuromuscular monitor**
		A4 – Wrong amount administered	**Inadequate neuromuscular block for procedure**	**Clinical observation and neuromuscular transmission monitor (if used)**	**L**	**M**	
Information exchange		**Details**					
A1 – Activate		States: Inactive, Continuous infusion, Bolus injection					

7.7.1 Monitor inspired inhalation agent concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Concentration not monitored**	**Patient too light or too deep**	**Clinical signs – HR, ECG, arrythmias** **Inspired inhalation agent alarms**	**L**	**H**	**Use of inspired / expired agent alarms** **Improve the display design** **Encourage 'standard check' by manual recording of values**
		R2 – Concentration misread	**Patient too light or too deep**	**Clinical signs – HR, ECG, arrythmias**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		Typically 1 – 2 MAC [MAC – Minimum Alveolar Concentration – exact value depends on the agent]					

7.7.2 Monitor inspired O_2 concentration.

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Concentration not monitored**	**Hypoxic mixture**	**Forcing function preventing hypoxic mixture** **FiO_2 and SpO_2 alarms**	**L**	**H**	**Encourage 'standard check' by manual recording of FiO_2 values**
		R2 – Concentration misread	**Hypoxic mixture**		**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		FiO_2 reading on the monitor – should be between 0.3 (30%) and 1.0 (100%)					

7.8 Adjust anaesthetic concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A4 – Dosage adjusted by wrong amount**	**Underdose or overdose**	**Monitoring of cardio-vascular stability and depth of anaesthesia**	**L**	**H**	**Ensure the inspired and expired inhalation concentration (Fractional Inhalation Agent) is monitored** **Encourage 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
A2 – Adjust		Range of settings on vaporiser is low > high, set by turning the dial. The required rate for maintenance is usually 0.5 – 2 MAC, exact value depending on the patient's response. Anaesthetist may use a proxy indicator of patient's response (e.g. BP) and use this as the basis for adjusting the anaesthetic concentration, hence this task step comprises a hierarchical control relationship [vaporiser setting > concentration > end-tidal gases > patient response]					

8.1 Administer oxygen at 100% concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A4 – Wrong amount of oxygen supplied**	**Hypoxia**	**Immediate**	**L**	**H**	**Cross-check that oxygen is supplied**
		A8 – Oxygen not supplied					
Information exchange		**Details**					
A1 – Activate		As for 7.2					

8.2 Insert oral airway

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Airway inserted incorrectly**	**Airway is compromised / obstructed**	**Clinical observation and patient monitoring (SpO_2)**	**L-M**	**M-H**	**Ensure regular practice at airway insertion** **Ensure use of a difficult airway protocol**
		A6 – Indirect size used					**Apply OPA size formula**
Information exchange		**Details**					
A1 – Activate		Airway states: open, occluded. Indicators of airway state: leaking air; presence of $ETCO_2$ reading on monitor; chest movement.					

8.3 Insert laryngeal mask airway

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Airway inserted incorrectly**	**Airway is compromised / obstructed**	**Clinical observation and patient monitoring**	**L-M**	**M-H**	**Ensure regular practice at airway insertion** **Ensure use of a difficult airway protocol**
		A6 – incorrect size used					**Apply LMA size formula**
Information exchange		**Details**					
A1 – Activate		Airway states: open, occluded. Indicators of airway state: leaking air; presence of $ETCO_2$ reading on monitor; chest movement.					

8.4 Insert tracheal tube

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Tube inserted incorrectly**	**Airway is compromised**	**Clinical observation and patient monitoring**	**L-M**	**H**	**Ensure regular practice at airway insertion** **Ensure use of a difficult airway protocol**
		A6 – incorrect size used					**Apply ET size formula**
Information exchange		**Details**					
A1 – Activate		Airway states: open, occluded. Indicators of airway state: leaking air; presence of $ETCO_2$ reading on monitor; chest movement.					

8.5 Insert throat pack

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Inserted incorrectly**	**Airway is compromised / obstructed**	**Clinical observations**	**L-M**	**H**	**Design a throat pack that can be easily inserted and removed**
Information exchange		**Details**					
A1 – Activate		Airway states: open, occluded. Indicators of airway state: leaking air; presence of $ETCO_2$ reading on monitor; chest movement.					

8.6 Fix airway

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 / A9 – airway not fixed properly**	**Airway becomes displaced**	**5.1 / 13.1.2 Monitor oxygen saturation** **5.4 / 13.1.5 Monitor respiratory gas changes** **Monitoring of clinical signs** **Anaesthetist or assistant notices the bellows collapse or changes in ventilation**	**L**	**H**	**Cross-check of adequate airway fixation**
Information exchange		**Details**					
A1 – Activate		Airway states: open, occluded. Indicators of airway state: leaking air; presence of $ETCO_2$ reading on monitor; chest movement.					

9 Cover patient's eyes

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Eyes not covered**	**Corneal damage or drying**	**None**	**L**	**M-H**	**Cross-check that eyes have been covered**

10.1 Attach temperature probe

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Probe not attached**	**No reading of temperature – potential hypothermia or hyperthermia**	**11.1 Monitor temperature of patient**	**L – M**	**L – H**	**Establish a protocol for deciding when to use temperature probe**
		A5 – Probe not correctly positioned	**Incorrect reading of temperature – potential hypothermia or hyperthermia**				

10.2 Attach central venous pressure monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not attached**	**Under- or over-transfusion of patient**	**11.2 / 13.1.3 Monitor central venous pressure monitor**	**L**	**M**	**Establish a protocol for deciding when to use CVP monitor**

10.3 Attach urinary output monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not attached**	**Inadequate monitoring of urinary output**	**11.3 / 13.1.7.2 Monitor urinary output monitor**	**L**	**M**	**Establish a protocol for deciding when to use urinary output monitor**

10.4 Attach peripheral nerve stimulator

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Stimulator not attached**	**Unable to monitor neuromuscular transmission**	**11.4 Monitor degree of neuromuscular block**	**H**	**M**	**Establish a protocol for deciding when to use nerve stimulator** **Make nerve stimulator readily available**

11.1 Monitor temperature of patient

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Temperature not monitored** **R2 – Temperature misread**	**Hypothermia or hyperthermia**	**Temperature alarm**	**L**	**L-H**	**Encourage a 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		Value on monitor display. Normal parameters: 36 – 37.5^{O}C					

11.2 Monitor central venous pressure

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Not read** **R2 – Misread**	**Low blood volume is missed**	**Monitoring of other vital signs (e.g. pulse)** **Blood pressure alarm**	**L**	**L**	**Encourage a 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		Value on monitor display. Normal parameters: 2 – 6 cm of water					

11.3 Monitor urine output

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Not read** **R2 – Misread**	**Indication of peripheral blood flow (kidney perfusion) is missed** **Insufficient fluid given, leading to hypovolaemia**	**13.1.4 Monitor heart rate and rhythm**	**M**	**M – H**	**Encourage a 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		At least 0.5 ml/kg/hr					

11.4 Monitor degree of neuromuscular block

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Not monitored**	**Neuromuscular block inadequate during surgery** **Residual neuromuscular block, leading to patient breathing inadequate post-operatively**	**Clinical observation**	**H**	**L-M**	**Encourage a 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		Normal parameter for successful block: T_1 is 0 – 25% of T_0 (where T_0 is the control twitch height)					

12.1 Switch off IV infusion for transfer to theatre

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Not switched off**	**Fluid leakage** **IV bleeds back**	**None**	**L**	**L**	**Cross-check by assistant**
Information exchange		**Details**					
A3 – Deactivate		States: On, Off					

12.2 Remove IV set from induction room device

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Tube not disconnected**	**Movement impeded** **Injury to patient or damage to equipment during movement**	**12.4 Check lines are secure** **12.6 Move trolley into theatre**	**L**	**L-M**	**Cross-check by assistant**

12.3.1 to 12.3.8 Disconnect monitors

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not disconnected**	**Movement impeded** **Injury to patient or damage to equipment during movement**	**12.4 Check lines are secure** **12.6 Move trolley into theatre**	**L**	**L-M**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor disconnections** **Telemetry**

12.3.9 Put monitors in standby mode

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Item not set in standby mode**	**Alarm sounds inappropriately**	**Immediate**	**H**	**L**	**Use of a context-sensitive alarm that detects when the machine is not being used**
Information exchange		**Details**					
A3 – Deactivate		As for 1.12.5					

12.4 Confirm lines on patient are secure

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Lines not checked**	**Disconnection of IV, IA or monitoring lines** **Injury to patient (criticality highest if IA line is involved)** **Movement impeded**	**12.6 Move trolley into theatre**	**L**	**L-H**	**Cross-check that lines are secure**
Information exchange		**Details**					
E2 – Extract		Visual inspection					

12.5 Check patient is secure on trolley

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Patient not checked**	**Injury to patient during movement**	**12.6**	**L**	**H**	**Assistant check – this may need to be made the direct responsibility of someone other than the anaesthetist**
Information exchange		**Details**					
E2 – Extract		Visual inspection					

12.6 Move trolley into theatre

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 / A5 / A7 – Trolley moved in an inappropriate manner**	**Manual handling injury to staff** **Damage to equipment**	**None**	**L**	**L-H**	**Ergonomic design of trolley and pathway** **Training in transfer technique**

12.7.1 Secure table and trolley

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Table and trolley not secured**	**Injury to patient or staff during transfer**	**12.7.3 Move patient**	**L**	**M-H**	**Ergonomic design of trolley** **Training in transfer technique**

12.7.2 Insert movement device between trolley and table

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Movement device not placed correctly**	**Injury to patient or staff during transfer**	**13.7.3; 15.4.4**	**L**	**M-H**	**Training in transfer technique**
		A8 – Movement device not inserted	**Injury to patient or staff during transfer**	**Immediate**	**L-M**	**H**	**Establish a protocol for using movement devices**

12.7.3 Move patient using movement device

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 / A3 / A4 – Patient mishandled**	**Injury to patient or staff**	**Immediate**	**L**	**H**	**Manual handling training** **Have a member of staff take charge of patient movement**

12.7.4 Remove movement device

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**None**					

12.7.5 Move trolley

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 / A5 / A7 – Trolley moved in an inappropriate manner**	**Manual handling injury to staff** **Damage to equipment**	**None**	**L**	**L-H**	**Ergonomic design of trolley and pathway** **Training in transfer technique**

12.8.1 Connect pulse oximeter

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Oximeter not connected**	**No SpO_2 reading**	**13.1.2 Monitor oxygen saturation**	**L**	**H**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor connection** **Telemetry**
		A5 – Oximeter not correctly positioned	**Incorrect SpO_2 reading**				**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

12.8.2 Connect blood pressure monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – BP monitor not connected**	**No BP reading**	**13.1.3 Monitor blood pressure**	**L**	**H**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor connections** **Telemetry**
		A5 – BP monitor not correctly positioned	**Incorrect BP reading**		**L-M**		**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

12.8.3 Connect ECG monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A6 – ECG monitor not connected**	**No ECG reading**	**13.1.4 Monitor heart rate and rhythm**	**L**	**H**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor connections** **Telemetry**
		A5 – ECG monitor not correctly positioned	**Incorrect ECG reading**		**M**		**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

12.8.4 Connect gas / agent monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Analyser not connected**	**Inadequate monitoring of inhaled and exhaled gases**	**13.1.5**	**L**	**M-H**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor connections** **Telemetry**

12.8.5 Connect temperature probe

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Probe not connected**	**No reading of temperature – potential hypothermia or hyperthermia**	**13.1.6**	**L-M**	**L-H**	**Single port for all monitor connections** **Use of a "head-box"**
		A5 – Probe not correctly positioned	**Incorrect reading of temperature – potential hypothermia or hyperthermia**	**13.1.6**			**Cross-check of monitor connections** **Telemetry**

12.8.6 Connect central venous pressure monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not connected**	**Inadequate reading of blood pressure**	**13.1.3**	**L**	**M**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor connections** **Telemetry**

12.8.7 Connect urinary output monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not connected**	**No monitoring of urinary output**	**13.1.7.2**	**L**	**M**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor connections** **Telemetry**

12.9.1 Set up theatre IV infusion set

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Tube not connected**	**IV fluids / medication not administered**	**Failure of fluids / drugs noticed through clinical signs**	**L**	**H**	**Cross-check of IV set**
		A7 – Set up incorrectly		**Infusion set alarms (if automatic device being used)**	**M**		

12.9.2 Start fluid administration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Device not started**	**No fluid administered**	**Pulse and BP changes** **13.1.7.2 Monitor urine output [NB this is a late sign]**	**L**	**L-H**	**Cross-check of fluid administration**
Information exchange		**Details**					
A1 – Activate		As for 12.1					

13.1.1 Monitor patient's level of responsiveness

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Level of responsiveness not assessed**	**Patient may be too light**	**Immediate**	**L**	**H**	**Ensure use of monitors (e.g. BP, HR, end-tidal volume)** **Context-specific monitoring / alarms**
		R2 – Level of responsiveness incorrectly assessed	**Patient may be too light**	**Immediate**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		Patient remains unconscious, indicated by e.g. loss of eyelash reflex; U on AVPU scale					

13.1.2.1 Monitor inspired inhalation agent concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Concentration not monitored**	**Patient too light or too deep**	**Clinical signs – HR, ECG, arrythmias** **Inspired inhalation agent alarm** **Depth of anaesthesia alarm**	**L**	**H**	**Use of inspired / expired agent alarms** **Improve the display design** **Encourage 'standard check' by manual recording of values** **Compulsory use of depth of anaesthesia monitoring**
		R2 – Concentration misread	**Patient too light or too deep**	**Clinical signs – HR, ECG, arrythmias** **Depth of anaesthesia alarm**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		0.5 – 2 MAC depending on patient response					

13.1.2.2 Monitor inspired O_2 concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Concentration not monitored**	**Hypoxic mixture**	**Forcing function preventing hypoxic mixture** **FiO_2 and SpO_2 alarms**	**L**	**H**	**Encourage 'standard check' by manual recording of FiO_2 values**
		R2 – Concentration misread	**Hypoxic mixture**		**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		As for 7.7.2					

13.1.3 Monitor oxygen saturation

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – SpO_2 not monitored**	**Hypoxia**	**Alarm**	**L**	**H**	**Context-specific alarms that take into account what the anaesthetist is doing at the time** **Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
Information exchange		**Details**					
M1 – Monitor		As for 5.1					

13.1.4 Monitor blood pressure

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – BP not monitored**	**Hypotension or hypertension**	**Alarm**	**L**	**M-H**	**Context-specific alarms that take into account what the anaesthetist is doing at the time Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
		R2 – BP misread	**Hypotension or hypertension**	**Alarm**	**L**	**M-H**	
Information exchange		**Details**					
M1 – Monitor		As for 5.2. Includes central and pulmonary monitors if in use					

13.1.5 Monitor heart rate and rhythm

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Not monitored**	**Arrythmia, tachycardia or bradycardia missed**	**Alarm**	**L**	**H**	**Context-specific alarms that take into account what the anaesthetist is doing at the time Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
		R2 – Misread	**Arrythmia, tachycardia or bradycardia missed**	**Alarm**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		As for 5.3					

13.1.6 Monitor respiration & respiratory gas traces

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Respiratory rate not monitored**	**Failure to identify:** • **Respiratory rate too high or too low** • **Hypoxia, hypocarbia or hypercarbia**	**Alarm**	**L**	**H**	**Context-specific alarms that take into account what the anaesthetist is doing at the time** **Prompt the anaesthetist to perform a 'standard check' (for example by manual recording of values)**
		R2 – Respiratory rate misread	**Failure to identify:** • **Respiratory rate too high or too low** • **Hypoxia, hypocarbia or hypercarbia**	**Alarm**	**L**	**H**	
Information exchange		**Details**					
M1 – Monitor		$ETCO_2$ = 3.5 – 8kPa, usually 5.2 approx. N_2O concentration maximum of 0.7 (70%). FiO_2 at least 0.3 (30%)					

13.1.7 Monitor temperature of patient

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Temperature not monitored** **R2 – Temperature misread**	**Hypothermia or hyperthermia**	**Alarm**	**L**	**L-H**	**Encourage a 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		As for 11.1					

13.1.8.1.1 Inspect swabs for blood

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C1 – Swabs not inspected**	**Significant blood loss missed**	**13.1.3 Monitor blood pressure** **13.1.4 Monitor heart rate and rhythm** **Surgeon informs anaesthetist of blood loss**	**L**	**H**	**Prompt the anaesthetist or assistant to perform a 'standard check'**
Information exchange		**Details**					
M1 – Monitor		Should be less than 10% of estimated blood volume. If greater than 10%: administer isotonic fluid. If greater than 20%: administer blood					

13.1.8.1.2 Inspect suction machine for blood

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Skill**	**C1 – Check omitted**	**Significant blood loss missed**	**13.1.3 Monitor blood pressure** **13.1.4 Monitor heart rate and rhythm** **Surgeon informs anaesthetist of blood loss**	**L**	**H**	**Prompt the anaesthetist or assistant to perform a 'standard check'**
Information exchange		**Details**					
M1 – Monitor		As for 13.1.8.1.1					

13.1.8.1.3 Inspect surgical wound

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C1 – Wound not checked**	**Significant blood loss missed**	**13.1.3 Monitor blood pressure 13.1.4 Monitor heart rate and rhythm Surgeon informs anaesthetist of blood loss**	**L**	**H**	**Prompt the anaesthetist or assistant to perform a 'standard check'**
Information exchange		**Details**					
M1 – Monitor		As for 13.1.8.1.1					

13.1.8.1.4 Listen for blood ‘sucking’

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C1 – Check not made**	**Significant blood loss missed**	**13.1.3 Monitor blood pressure 13.1.4 Monitor heart rate and rhythm Surgeon informs anaesthetist of blood loss**	**L**	**H**	**Prompt the anaesthetist or assistant to perform a ‘standard check’**
Information exchange		**Details**					
M1 – Monitor		There should be no sounds of this type					

13.1.8.2 Monitor urine output

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Not read** **R2 – Misread**	**Indication of peripheral blood flow (kidney perfusion) is missed** **Insufficient fluid given, leading to hypovoalemia**	**13.1.3 Monitor blood pressure** **13.1.4 Monitor heart rate and rhythm** **Surgeon informs anaesthetist of blood loss**	**M**	**M – H**	**Encourage a 'standard check' by manual recording of values** **Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		As for 11.3					

13.1.9 Record observations on observation chart

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Skill**	**I1 – Observations not recorded** **I2 – Observations recorded incorrectly**	**No record of anaesthetic care** **Incorrect record of anaesthetic care**	**None**	**L**	**H**	**Automated recording devices** **Encourage a 'standard check' by manual recording of values**
Information exchange		**Details**					
E1 – Enter		Vital signs (pulse, BP, respirations). Other recorded information may include central venous pressure, SaO_2, ET anaesthetic, respiratory gases etc. as appropriate					

13.2 Adjust anaesthetic concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A4 – Dosage adjusted by wrong amount**	**Underdose or overdose**	**Monitoring of cardio-vascular stability and depth of anaesthesia**	**L**	**H**	**Use of depth of anaesthesia monitor Ensure the inspired and expired inhalation concentration (Fractional Inhalation Agent) is monitored Encourage 'standard check' by manual recording of values Context-specific monitoring / alarms**
Information exchange		**Details**					
A2 – Adjust		As for 7.8					

13.3 Review / amend post-operative care requirements

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Selection	**Rule / Knowledge**	**S2 – Incorrect post-operative care ordered**	**Inappropriate post-operative care given**	**15.7.7 Inform recovery nurse of post-operative care requirements**	**L**	**H**	**Establish a protocol for deciding on post-operative care requirements**
Information exchange		**Details**					
M1 – Monitor / E1 – Enter		Target state determined by the pre-operative plan [task step 3.3 in pre-operative tasks]. If there is a mismatch between patient's actual condition and expected condition, need to amend the care plan					

13.4 Inform recovery nurse of post-operative analgesia requirements

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Skill**	**I1 – Nurse not informed**	**Delay in post-operative care**	**15.7 Hand over to recovery nurse**	**L**	**H**	**Recovery nurse to prompt anaesthetist** **Use of integrated care pathway** **Use of peri-operative care practitioner** **Data-link between theatre and recovery room**
		I2 – Nurse given incorrect information	**Ineffective post-operative care**				
Information exchange		**Details**					
E1 – Enter		Information provided: analgesia given during operation, drugs prescribed for post-operative period					

14.1 Monitor patient's level of responsiveness

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Level of responsiveness not assessed**	**Patient may be too light**	**Immediate**	**L**	**H**	**Use of depth of anaesthesia monitoring** **Ensure use of monitors (e.g. BP, HR, end-tidal volume)** **Context-specific monitoring / alarms**
		R2 – Level of responsiveness incorrectly assessed	**Patient may be too light**	**Immediate**	**L**	**H**	
Information exchange		**Details**					
M2 – Monitor		Patient is conscious, e.g. A on AVPU scale					

14.2 Discontinue anaesthetic drugs

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – Drugs not discontinued**	**Unconsciousness is prolonged**	**14.1 Monitor patient's level of responsiveness 13.1.5 Monitor respiration and respiratory gas traces Depth of anaesthesia monitor**	**L**	**L**	**Context-specific monitoring / alarms**
Information exchange		**Details**					
A3 – Deactivate		States: Off, Low, High					

14.3 Administer drugs to reverse neuromuscular blockade

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – Drugs not administered when required**	**Paralysis is prolonged, patient may not breathe**	**14.1 Monitor patient's level of responsiveness**	**L**	**L-M**	**Establish a protocol for the use of reversal drugs**
		A4 – Wrong amount administered	**Underdose or overdose**				**Ensure clinical signs are monitored during administration Context-specific monitoring / alarms**
Information exchange		**Details**					
A1 – Activate / M2 – Monitor		States: Off, Low, High					

14.4 Administer oxygen at 100% concentration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A4 – Wrong amount of oxygen supplied**	**Hypoxia**	**Immediate**	**L**	**H**	**Cross-check that oxygen is supplied**
		A8 – Oxygen not supplied					
Information exchange		**Details**					
A1 – Activate		As for 7.2					

14.5.1 Remove throat pack

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A9 – Throat pack not removed**	**Airway compromised or obstructed**	**Immediate or in post-operative care unit**	**L**	**H**	**Use of a reminder** **Tie the throat pack to the LMA** **Ensure end of throat pack is left visible at all times** **Recovery nurse to check in post-operative care unit**

14.5.2 Unfix artificial airway

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**						

14.5.3 Apply suction to trachea

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Suction not applied**	**Hypoxia Pulmonary aspiration of secretions**	**Immediate**	**L**	**H**	**Ensure standard airway management protocols are followed**
		A1 – Suction applied incorrectly	**Suction ineffective – patient aspirates**				

14.5.4 Place patient in left lateral position

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Patient not positioned**	**Risk of compromised airway**	**Immediate**	**L**	**H**	**Ensure standard airway management protocols are followed**

14.5.5 Uncover patient's eyes

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A9 – Eyes not uncovered**	**Patient discomfort Eye movements obscured**	**Immediate**	**L**	**M**	**Cross-check that eyes are uncovered**

14.5.6 Remove artificial airway

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 – Artificial airway removed before patient has control of airway**	**Laryngospasm**	**Immediate**	**L**	**H**	**Ensure facial expressions and eye opening are observed before airway is removed**

15.1 Continue oxygen administration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Oxygen discontinued**	**Hypoxia**	**Immediate**	**L**	**H**	**Cross-check that oxygen has been reapplied**
Information exchange		**Details**					
A1 – Activate		As for 7.2					

15.2 Interrupt intravenous fluid administration

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Not interrupted**	**Fluid leakage** **IV bleeds back**	**None**	**L**	**L**	**Cross-check that fluid has been interrupted**
Information exchange		**Details**					
A3 – Deactivate		States: On, Off					

15.3.1 to 15.3.9 Disconnect monitors

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Monitor not disconnected**	**Movement impeded** **Injury to patient or damage to equipment during movement**	**15.4 Move patient from operating table onto trolley**	**L**	**L-M**	**Single port for all monitor connections** **Use of a "head-box"** **Cross-check of monitor disconnections** **Telemetry**

15.4.1 Retrieve trolley

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 / A5 / A7 – Trolley moved in an inappropriate manner**	**Manual handling injury to staff** **Damage to equipment**	**None**	**L**	**L-M**	**Ergonomic design of trolley and pathway** **Training in transfer technique**

15.4.2 Secure table and trolley

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Table and trolley not secured**	**Injury to patient or staff during transfer**	**15.4.4 Move patient**	**L**	**M-H**	**Ergonomic design of trolley** **Training in transfer technique**

15.4.3 Insert movement device between trolley and table

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A5 – Movement device not placed correctly**	**Injury to patient or staff during transfer**	**15.4.4**	**L**	**M-H**	**Training in transfer technique**
		A8 – Movement device not inserted	**Injury to patient or staff during transfer**	**Immediate**	**L-M**	**H**	**Establish a protocol for using movement devices**

15.4.4 Move patient using movement device

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 / A3 / A4 – Patient mishandled**	**Injury to patient or staff**	**Immediate**	**L**	**H**	**Manual handling training** **Have a member of staff take charge of patient movement**

15.4.5 Remove movement device

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**None**					

15.5 Place patient in left lateral position

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Patient not positioned**	**Risk of compromised airway**	**Immediate**	**L**	**H**	**Ensure standard airway management protocols are followed**

15.6 Move trolley into recovery room

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A2 / A5 / A7 – Trolley moved in an inappropriate manner**	**Manual handling injury to staff** **Damage to equipment**	**None**	**L**	**L-M**	**Ergonomic design of trolley and pathway** **Training in transfer technique**

15.7.1.1 Connect pulse oximeter

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – Oximeter not connected**	**No SpO_2 reading**	**15.7.8 Monitor vital signs**	**L**	**H**	**Ensure compliance with guidelines** **Cross-check that oximeter is attached**
		A5 – Oximeter not correctly positioned	**Incorrect SpO_2 reading**				**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

15.7.1.2 Connect blood pressure monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A8 – BP monitor not connected**	**No BP reading**	**15.7.8 Monitor vital signs**	**L**	**H**	**Ensure compliance with guidelines Cross-check that BP monitor is applied**
		A5 – BP monitor not correctly positioned	**Incorrect BP reading**		**L-M**		**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

15.7.1.3 Connect ECG monitor

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill / Rule**	**A6 – ECG monitor not connected**	**No ECG reading**	**15.7.8 Monitor vital signs**	**L**	**H**	**Ensure compliance with guidelines Cross-check that ECG monitor is applied**
		A5 – ECG monitor not correctly positioned	**Incorrect ECG reading**		**M**		**Ensure there is a check of signal quality. Use a 'signal quality' alarm**

15.7.2 Inform recovery nurse of post-operative care requirements

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Communication	**Skill**	**I1 / I3 – Nurse is not given complete information**	**Ineffective post-operative care**	**Immediate**	**L**	**H**	**Formal protocol for handover**
		I2 – Nurse is given incorrect information		**Postoperative care**			**Use of integrated care pathway** **Use of peri-operative care practitioner** **Data-link between theatre and recovery room**
Information exchange		**Details**					
E1 – Enter		Patient's details, surgery done, drugs administered, fluids administered, special requirements (e.g. ICU, HDU)					

15.7.3 Restart IV infusion if required postoperatively

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Infusion not restarted**	**No infusion** **Dehydration** **No compensation of fluid volume** **Hypotension**	**Check by anaesthetist or recovery nurse**	**L**	**L-H**	**Cross-check that IV has been restarted**
Information exchange		**Details**					
A1 – Activate		On, Off					

15.7.4 Monitor vital signs

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Retrieval	**Rule**	**R1 – Vital signs not monitored**	**Change in patient's condition not identified**	**Alarm**	**L**	**H**	**Context-specific monitoring / alarms**
Information exchange		**Details**					
M1 – Monitor		As for 5.1 – 5.3					

16.1 Check details on anaesthetic chart

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C2 – Check not made**	**Information omitted** **Incomplete record of anaesthetic**	**None (unless recovery nurse notices discrepancy with nursing records)**	**L**	**L**	**Use of automatic recording device**
Information exchange		**Details**					
E1 – Enter / M2 – Monitor		Anticipated cue is that the information recorded matches what the anaesthetist expected to be there Information needed – as for 13.1.9					

16.2 Check post-operative care instructions

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Check	**Rule**	**C1 – Details not checked** **Ineffective post-operative care**	**Information omitted**	**Postoperative care**	**L**	**L-H**	**Formal protocol for handover** **Use of integrated care pathway** **Use of peri-operative care practitioner (e.g. Kneebone et al., 2006)**
Information exchange		**Details**					
E1 – Enter / M2 – Monitor		Anticipated cue is that the information recorded matches what the anaesthetist expected to be there Information needed – as for 13.4					

16.3 File documentation

Class	Level	Error mode	Consequences	Recovery	P	Criticality	Remediation
Action	**Skill**	**A8 – Documentation not filed**	**No record of anaesthesia**	**None**	**L**	**H**	**Use of automatic recording device** **Automatic transfer of data to electronic patient record**
Information exchange		**Details**					
E1 – Enter		Patient's case notes					

4. Discussion

The main aim of this human reliability analysis was to provide a systematic description of anaesthesia delivery and consider the associated human factors issues. The use of HTA and SHERPA as the analytical method gives emphasis to the behaviours performed by the anaesthetist, as opposed to other types of task analysis that place emphasis on the structure of the task itself. The addition of GEMS provides a theoretical framework onto which each task step can be mapped and the use of SGT provides further details about the information processing that takes place.

However, while the analysis contributes to the understanding of anaesthesia practice, there are some caveats that should be taken into account. The first is that this analysis describes a 'generic' anaesthetic delivery; while it captures much of what takes place during most types of case, it is probable that the description would change in more specialised operations, for example cardiac surgery or operations carried out under regional anaesthesia. However, the analysis presented here provides a suitable template that can be modified for more unusual instances of anaesthesia practice.

The second issue is that anaesthesia practice (and hence, the exact content of the SHERPA) depends to some extent on the circumstances of each case. For example, while in many situations monitoring the temperature of the patient is of low or medium criticality, it becomes of high criticality if the patient is being cooled for a heart bypass. Similarly, monitoring inhalation agents is of highest criticality when anaesthetising neonates who are more sensitive to volatile agents. For some task steps, the criticality of an error can vary across the patient population. For example, picking up the wrong drug in the induction room would be a highly critical error for a small number of patients who are allergic to the drug being used, but of lower criticality in a larger number of patients. Again, an attempt has been in the current study to take into consideration what rating would apply in most cases. It should be noted, however, that the some of the data collected may be specific to the sites at

which data collection took place, and may be liable to change with practice at other sites.

Thirdly, as alluded to in the introductory section, GEMS has had little evaluation as a practical HRA tool (as opposed to a post-hoc classification scheme), and the formulation of GEMS used in this study should be regarded as a prototype. Future work could be carried out to evaluate the use of GEMS to predict errors or to inform the design of interventions in anaesthetic settings.

Fourthly, it is not entirely clear how the SGT translates to information handling in a medical environment. It would appear from the current study that it is of some use in capturing the information demands, although the process control terminology might not map very well onto medical tasks. Again, more empirical work to establish the link between the SGT and actual task activity would be useful.

Finally, while HTA aims to provide a comprehensive description of task-related behaviour, it is often considered to be more representative of physical actions than of the cognitive aspects of a task. Hierarchical task analysis does go some way to describing the cognitions involved in carrying out a task and SGT represents an attempt to make these more explicit. However, many analysts turn to more specific 'cognitive task analysis' (CTA) to address such issues in more detail than HTA commonly provides [12, 42-45]. Hierarchical Task Analysis remains a useful starting point for task analysis even if CTA is ultimately employed, though, because the former tends to provide a more rigorous description of the task's structure [46].

As a closing comment, the analysis undertaken by the authors is presented here in its entirety for the benefit of those working in human factors or anaesthesia, either as practitioners or as researchers. It is hoped that the information provided by this report will inspire future work in these areas.

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