Pediatric Anesthesia

Pediatric Anesthesia ISSN 1155-5645

ORIGINAL ARTICLE

Emergency pediatric anesthesia – accessibility of information

Hannah King[1], Georgina E.M. Pipe[1], Sarah L. Linford[1], Iain K. Moppett[2] & James A.M. Armstrong[1]

1 Department of Anaesthesia, Nottingham University Hospitals NHS Trust, Nottingham, UK
2 Anaesthesia & Critical Care Research Group, Division of Clinical Neuroscience, University of Nottingham, Nottingham, UK

Keywords
pediatric; patient safety; checklist; information resources; smartphone applications; emergency algorithms

Correspondence
Hannah King, Department of Anaesthesia, Nottingham University Hospitals NHS Trust, Derby Road, Nottingham, NG7 2UH, UK
Email: Hannah.king@nuh.nhs.uk

Section Editor: Brian Anderson

Accepted 22 September 2014

doi:10.1111/pan.12558

Summary

Background: Emergency pediatric situations are stressful for all involved. Variation in weight, physiology, and anatomy can be substantial and errors in calculating drugs and fluids can be catastrophic.
Objectives: To evaluate the reliability of information resources that anesthetic trainees might use when faced with common pediatric emergencies.
Methods: Anesthetic trainees from a single UK deanery were recruited and timed while they identified 18 predetermined pieces of information from three Advanced Pediatric Life Support (APLS) scenarios. The two most popular smartphone applications identified from a previous survey, PaedsED (PaedsED. iED limited, Version 1.0.8, Updated March 2011. ©2009) and Anapaed (AnaPaed. Thierry Girard, Version 1.4.2, Updated Nov 2, 2012. ©Thierry Girard), the British National Formulary for Children (cBNF) and trainee's inherent knowledge were compared with a local, check-list style, handbook of pediatric emergency algorithms – Pediatric Anesthetic Emergency Data sheets (PAEDs).
Results: Twenty anesthetic trainees were recruited. The fastest source of information was the trainees own knowledge (median 61 s, IQR 51–83 s). Second fastest was PAEDs (80, [59–110] s), followed by PaedsED (84, [65–111]). The most accurate source overall was PaedsED (100, [83–100]) although the accuracy varied between scenarios. The handbook was rated as the most popular resource by the trainees.
Conclusion: Although fastest, trainees own knowledge is inaccurate, highlighting the need for additional, rapidly accessible, information. Of the two smartphone applications, PaedsED proved to be fast, accurate, and more popular, while Anapaed was accurate but slow to use. The PAEDs handbook, with its checklist-style format, was also fast, accurate and rated the most popular information source.

Introduction

The management of emergency situations can be challenging for all involved. This is particularly true in pediatric anesthesia, where there is an increased need for rapid calculation of medication doses, equipment size, and recall of management protocols. Access to accurate, up-to-date information is essential to improve decision making in these stressful situations and reduce the potential for errors in calculating and prescribing. Therefore, what is needed is a robust system for obtaining or calculating information to ensure patient safety. An interesting parallel can be drawn here with emergency management within the aviation industry. Here, emergency situation management plans are specifically NOT learnt, but are read from a checklist when the need arises.

In 2012, a survey of anesthetic trainees working within the Nottingham and East Midlands School of Anesthesia was performed (J.A.M Armstrong, H. King, unpublished work). Trainees were asked about the sources of information that they would use to access guidelines or dosing information when managing pediatric emergencies. Information sources identified included the hospital intranet, internet searches, and smartphone applications. The survey also identified a high level of anxiety in dealing with these situations and the need for a more easily accessible but accurate source of information.

Despite the availability of several pediatric anesthesia or emergency medicine apps, concerns have been raised about accuracy and the appropriateness of accessing smartphones in clinical areas (1). As a result, we developed a handbook of 'checklist style' emergency pediatric guidelines, entitled Pediatric Anesthetic Emergency Data sheets (PAEDs) that would be available in all areas where pediatric emergencies were managed. The handbook is composed of two sections; 'Age by Page' and 'Guidelines'. The 'Age by Page' section consists of a single page for each age from 'term baby' up to 12 years, containing: WHO weight range, normal physiological variables, and precalculated data for airway devices, resuscitation, and anesthetic drugs. In the 'Guidelines' section, hospital approved guidelines were formatted as flow charts or tables to allow rapid interpretation and hence application to immediate patient management. Approval for the completed booklet was obtained from Pediatric Guideline group, Medicine Management Committee, Drug and Therapeutic Committee, and Theater Governance group as well as being checked by Pediatric Pharmacy. The aim of this study was to evaluate the new guideline book and compare its performance and acceptability against existing popular information sources.

Methods

Three scenarios from Advanced Pediatric Life Support (APLS) (2) teaching material were selected at random by a nonanesthetic colleague unrelated to the study (2-year-old girl with croup, 10-month-old girl found submerged in water with basic life support in progress and a 8-year-old boy pedestrian road traffic accident victim). Six pieces of information relevant to each scenario were identified, forming 18 questions (Appendix S1). Before subjects were recruited, each of the information sources was examined independently by the two primary investigators to create an answer sheet. The 'number of available' answers that could be identified from each source was noted and later used in the analysis. The two most popular smartphone applications identified by the survey [PaedsED (3) and Anapaed (4)], the British National Formulary for Children (cBNF) and trainees inherent knowledge were compared with the PAEDs handbook. A standardized study proforma (Appendix S1) was written explaining the aim of the study, giving clinical information for each scenario and explaining the five information sources. A brief tutorial and demonstration of the apps and PAEDs handbook was given prior to the start of the study. Trainees that had rotated to the Hospital in the month that the evaluation took place and therefore with limited exposure to the institutions PAEDs handbook took part in the evaluation.

Twenty anesthetic trainees of UK intermediate or higher level of specialty training years 4–7 (ST 4–7) volunteered to take part in the evaluation. Each participant was timed, by a study investigator, while they identified and demonstrated to the investigator the information requested. If a participant was unable to identify a requested item, or felt that it would not be available in a particular source, they were able to 'pass' and the time to request this 'pass' was recorded. The order of the scenarios was also randomized to compensate for 'learning effects' in using the new information sources.

For each clinical scenario and information source combination, three outcomes were analyzed; time to find data, number of answers available and accuracy (number of correctly identified answers from number available). Finally, the study participants were asked to rate the ease of use for each of the information sources using an 'ease of use' rating score (1–10).

Data were recorded using a standardized data collection sheet and analyzed using Microsoft® Excel® Spreadsheet 2010 version. The results from all three scenarios were combined for analysis, giving a global assessment of each information resource. Scenarios were then analyzed individually. Data are presented as median [interquartile range] and radar plots. Data were normalized to a 0–100 scale. Time to find information values is presented in a reverse axis for ease of comparison.

Results

Twenty anesthetic trainees were involved in the evaluation, with an equal male to female distribution, and nine of intermediate and 11 of higher level of training. No information source apart from 'inherent knowledge' could provide all 18 requested answers (cBNF 8, AnaPaed 14, PAEDs 16, PaedsED 17). Accuracy was based on the study participant being able to demonstrate an available answer, hence, the cBNF had an accuracy of 100% despite only having eight available answers.

Analysis of the combined results for all scenarios showed that the trainees own knowledge was the fastest source (61 s, [51–83]) while the cBNF was the slowest

Table 1 Combined results for scenarios. Data presented as Median [IQR]

	Own knowledge	PaedsED	British National Formulary for Children	AnaPaed	Pediatric Anesthetic Emergency Data sheets
Time (s)	61 [51–83]	84 [65–111]	138 [113–189]	114 [95–135]	80 [59–110]
Available answers (out of 18)	18	17	8	14	16
Accuracy[a] (%)	67 [50–83]	100 [83–100]	100 [67–100]	100 [79–100]	100 [80–100]
Ease of use rating score (1–10)	7 [6–8]	7 [7–8]	2 [1–2]	6 [5–7]	9 [8–9]

Ease of use rating score – 1 = worst, 10 = best.
[a]Accuracy = number of correct answers/number of available answers from source.

(138 s, [113–189]). Table 1 shows the combined results for time, number of available answers, accuracy, and 'ease of use' rating score. The data are presented schematically in Figure 1.

Individual scenario data are presented in Table 2 and Figures 2, 3 and 4. The most accurate source was different in all three scenarios (smartphone applications and handbook.)

The handbook was rated as the most popular resource, followed by PaedsED and AnaPaed.

Discussion

This study showed that a 'checklist style' collection of emergency algorithms is at least as effective as currently available information sources in the management of pediatric emergency scenarios. This way of presenting emergency information also proved to be extremely popular among the anesthetic trainees who evaluated it.

Our original survey identified the need for a rapidly accessible source of information to assist anesthetic trainees when managing pediatric emergencies to ensure evidence-based practice and reduce potential errors. NHS Trusts have a large library of either locally or nationally approved guidelines which are used to provide evidence-based patient care. These documents are comprehensive and well referenced; however, they are generally lengthy documents located on the hospital intranet site. To access these guidelines in a clinical area, access to a computer is required, which is often remote from the patient. In addition, the location of the guideline is often not an intuitive path to follow, and the whole process is time consuming.

The survey also identified the need for a cognitive aid to assist trainees in either remembering or checking the numerous formulae that are used in pediatric anesthesia. Mental arithmetic is an essential component of managing pediatric patients. However, at moments of high stress or when we are called upon to manage infrequently seen cases errors may occur (5–8). Flin *et al.* (5) analyzed data obtained from over 200 anesthetists of all grades who completed the Operating Room Manage-

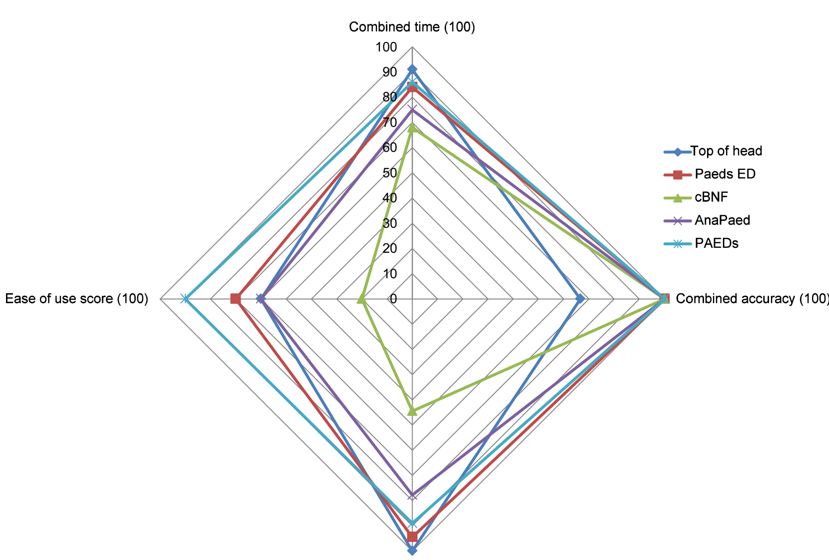

Figure 1 Combined scenarios results.

Table 2 Individual results for scenarios. Data presented as Median [IQR]

Scenario		Own knowledge	PaedsED	British National Formulary for Children	AnaPaed	Pediatric Anesthetic Emergency Data sheets
2 year, croup	Time (s)	73 [59–85]	110 [94–138]	164 [120–206]	133 [106–153]	116 [100–125]
	Accuracy (%)	67 [58–83]	100 [83–100]	67 [67–100]	75 [75–100]	80 [60–85]
10 month, near drowning	Time (s)	67 [43–99]	71 [59–96]	163 [127–208]	96 [85–105]	85 [64–103]
	Accuracy (%)	67 [50–71]	100 [100–100]	100 [67–100]	100 [100–100]	100 [95–100]
8 year, RTA	Time (s)	57 [51–61]	70 [63–88]	110 [99–128]	117 [95–131]	55 [47–62]
	Accuracy (%)	17[a] [17–50]	83 [83–100]	100 [100–100]	100 [95–100]	100 [100–100]

[a]Expected weight 31 kg, 17 trainees calculated wt 24 kg based on pre-2011 Advanced Pediatric Life Support formula (weight = [age + 4] × 2), accuracy based on this weight 67%.

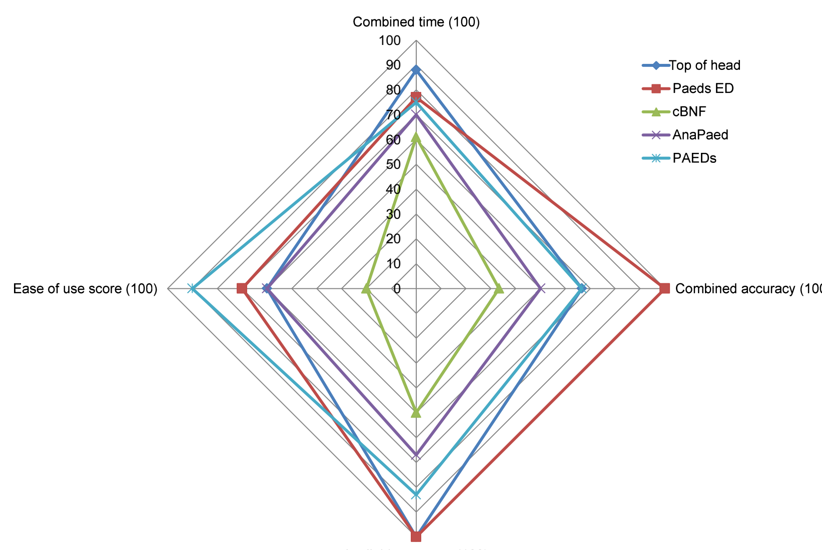

Figure 2 Two-year old, croup.

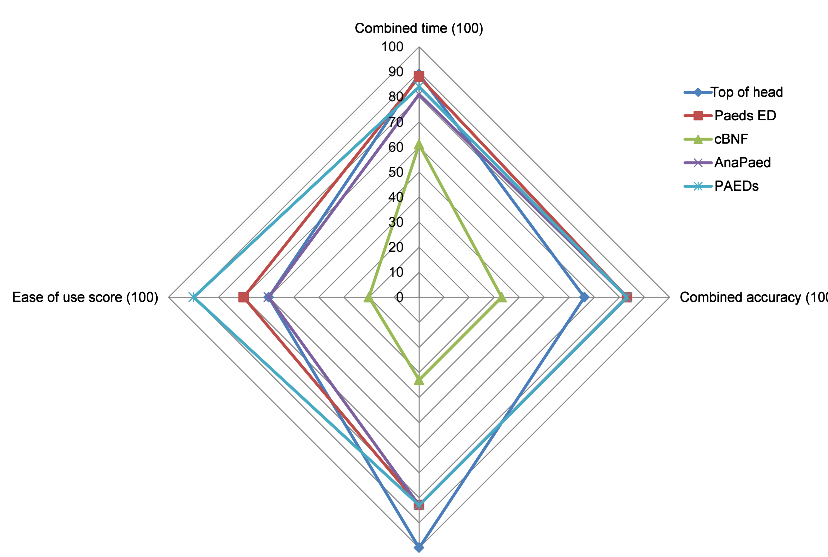

Figure 3 Ten-month old, near drowning.

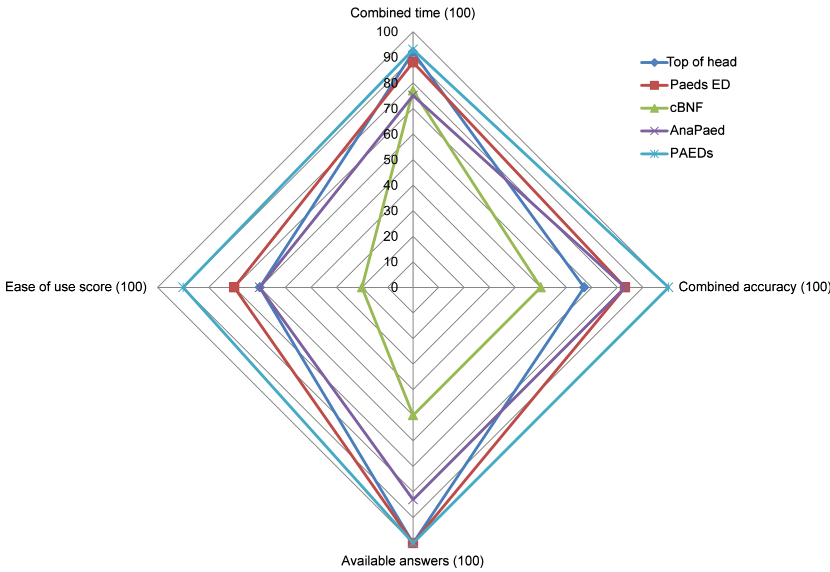

Figure 4 Eight-year old, RTA.

ment Attitudes Questionnaire (ORMAQ) which measures attitudes to stress, hierarchy, teamwork, and error. 70% agreed with the statement 'I am more likely to make errors in tense or hostile situations', while 83% agreed with 'I am less effective when stressed or tired'. Sexton *et al.* (8) found that medical staff, compared to aviation staff, are more likely to deny the effects of stress and fatigue. There is less published research regarding the effects of stress on cognitive function; however, LeBlanc *et al.* (6) studied experienced paramedics performing comparable drug calculations in a low-stress classroom environment vs a high-stress environment immediately after completing a human patient simulator scenario. They found that lower accuracy scores were achieved in the high-stress situation (43% vs 58%).

The weight of the critically ill child is required to allow calculation of appropriate dosage of medication and fluids. However, it is often impractical or unsafe to weight the child on arrival. As a result, there is the need for accurate rapid estimation of the patient's weight using formula, Broslow tapes or information from parents. Luscombe *et al.* (9,10) performed a retrospective study that showed existing weight estimation formula underestimated weight by a mean of 18%. They tested multiple formula and found that weight (kg) = (3 × age) + 7 was the most accurate. The fifth edition of the APLS manual 2011 (11) adopted this new formula for the 6- to 12-year age group but unfamiliarity with it is still prevalent. Our study showed an accuracy of only 17% for the 8-year-old scenario using the trainees own knowledge because of our expectation that this revised weight formula would be used rather than the pre-2011 formula. As a result of the incorrect choice of weight by our subjects, all other medication calculations were subsequently incorrect. However, both of the apps calculated medication doses based on a weight of 25 kg with no reference to a formula for this weight estimation. Repeated analysis of the trainees own knowledge for the 8-year-old scenario data, accepting the weight of 24 kg, gave an accuracy of 67% which was still lower than any other information source.

We did not record previous experience with any of the information sources evaluated; however, any bias due to familiarity would also apply to both the apps and cBNF as these sources were identified from the earlier trainee survey. Published literature comparing the speed of accessing data from different sources of information, that is, paper base compared to electronic information is lacking. However, there is an increasing volume of literature regarding the use of smartphone applications (apps) by medical professionals, medical students, and patients. Medical professionals and students are using them as educational resources, to aid disease diagnosis, as medical calculators, and for drug reference (12–15). Patients are increasingly accessing apps for disease self-monitoring (16), while medical institutions in combination with patients are using them for patient education, remote monitoring, and to aid communication with patients.

Payne *et al.* (1) performed an online survey of medical students and junior doctors in one UK healthcare region looking at smartphone ownership, patterns of medical apps usage, and acceptance of them as a source of information. Over 50% of both groups owned between one and five medically related apps. The authors found a difference in the type of app preferred by each group, with medical students favouring educational apps and doctors favouring disease management and drug reference apps. They also commented on concerns raised by survey participants regarding the appropriateness of accessing smartphones in the clinical environment, which supports locally held concerns regarding patients and possibly clinician's perceptions regarding the use of handheld devices, especially telephones, in clinical environments and is an area that warrants further study.

Despite a rapid growth in the use of medical apps, there is increasing concern regarding the lack of robust regulation and peer review involved to ensure the accuracy and reliability of app content (16,17). The level of professional medical involvement in the authorship, creation, and design of apps is extremely variable and information regarding evidence-based content, and peer review is often lacking. Customized apps to address particular areas of work are now being developed both by individuals and hospital departments (18–20). Apps developed from specific hospital written, reviewed, approved, and referenced guidelines provide a quick reference source of information to aid point of care decision making.

All these factors point to the need for a readily available, rapidly accessible source of information. If one looks at the, much compared, aviation industry, it is interesting to note that they specifically do not try and learn checklist for rare, but serious, emergency situations. Here, when such a situation arises, the necessary information and steps to be taken are read from a checklist. This obviously requires the correct checklist to be selected, but has the potential to massively reduce the potential for errors and omissions in management. Arriaga *et al.* (21) have shown that the use of checklists in the management of simulated operating room crises resulted in a significant improvement in adherence to critical management steps compared to scenarios where checklists were not used. This group, which includes Atul Gawande, author of 'The checklist manifesto' (22) and instigator of the WHO Surgical checklist, conclude that checklists have the potential to improve clinical practice and that work is required to determine the most appropriate medium (paper vs electronic).

With the decreasing levels of clinical experience seen in medicine today, is it time to swallow our pride and adopt a similar approach? Should one member of any resuscitation/emergency team be tasked with maintaining an overview and 'reading off' the checklist to ensure nothing is missed and that the team does not become task fixated in such a high-stress environment?

This paradigm shift in our thinking and management of rare, but serious, emergencies will require many thought and planning to implement, coupled with both simulation and clinical study to see if it achieves real results in terms of performance and team management. Further, work is also required to examine the use of smartphones and medical applications by the medical profession while managing medical emergencies, both in terms of acceptability and reliability.

Disclosure

Ethical approval was not required for this evaluation.

Funding

The study was funded by departmental resources.

Conflict of interest

Armstrong and King have a book based on the PAEDs handbook in press.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Study Questions and Study information proforma.

References

1 Payne KB, Wharrad H, Watts K. Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey. *BMC Med Inform Decis Mak* 2012; **12**: 121.

2 APLS Teaching material: simulations. Available at: http://www.alsg.org/learning/mod/page/view.php?id = 1469. Accessed 23 September, 2013.

3 PaedsED. iED limited, Version 1.0.8, Updated March 2011.©2009.

4 AnaPaed. Thierry Girard, Version 1.4.2, Updated Nov 2, 2012. ©Thierry Girard.

5 Flin R, Fletcher G, McGeorge P *et al.* Anaesthetists' attitude to teamwork and safety. *Anaesthesia* 2003; **58**: 233–242.

6 LeBlanc VR, MacDonald RD, McArthur B *et al.* Paramedic performance in calculating drug dosages following stressful scenarios in a human patient simulator. *Prehosp Emerg Care* 2005; **9**: 439–444.

7 LeBlanc VR. The effects of acute stress on performance: implications for health professions education. *Acad Med* 2009; **84**: S25–S33.

8 Bryan Sexton J, Thomas EJ, Helmreich RL. Error, stress, and teamwork in medicine and aviation: cross sectional surveys. *BMJ* 2000; **320**: 745–749.

9 Luscombe M, Owens B. Weight estimation in resuscitation: is the current formula still valid? *Arch Dis Child* 2007; **92**: 412–415.

10 Luscombe MD, Owens BD, Burke D. Weight estimation in paediatrics: a comparison of the APLS formula and the formula “weight = 3(age) + 7”. *Emerg Med J* 2011; **28**: 590–593.
11 Chapter 2. Why treat children differently? In: Samuels M, Wieteska S, eds. Advanced Paediatric Life Support Manual, 5th edn. Oxford: Blackwell Publishing Ltd., 2011: 7–13.
12 Mosa AS, Yoo I, Sheets L. A systematic review of healthcare applications for smartphones. *BMC Med Inform Decis Mak* 2012; **12**: 67.
13 Flannigan C, McAloon J. Students prescribing emergency drug infusion utilising smartphones outperforms consultants using BNFCs. *Resuscitation* 2011; **82**: 1424–1427.
14 Bhansail R, Armstrong J. Smartphone applications for pediatric anaesthesia. *Pediatr Anesth* 2012; **22**: 400–404.
15 Dasari K, White S, Pateman J. Survey of iPhone usage among anesthetists in England. *Anaesthesia* 2011; **66**: 630–631.
16 Huckvale K, Car M, Morrison C *et al*. Apps for asthma self-management: a systematic assessment of content and tools. *BMC Med* 2012; **10**: 144.
17 Haffey F, Brady RR, Maxwell S. A comparison of the reliability of smartphone apps for opioid conversion. *Drug Saf* 2013; **36**: 111–117.
18 Microguide, Southampton University Hospitals NHS Trust. Available at: http://itunes.apple.com/gb/app/microguide/id447171786?mt = 8. Accessed 11 March, 2014.
19 Paediatric Emergency Drugs, Evelina Children’s hospital, Guys and St Thomas’NHS trust. Available at: http://itunes.apple.com/gb/app/paediatric-emergency-drugs/id415663345?mt = 8%20. Accessed 11 March, 2014.
20 Hardyman W, Bullock A, Brown A *et al*. Mobile technology supporting trainee doctors’ workplace learning and patient care: an evaluation. *BMC Med Educ* 2013; **13**: 6.
21 Arriaga A, Bader A, Wong J *et al*. Simulation-Based Trial of surgical-crisis checklists. *N Engl J Med* 2013; **368**: 246–253.
22 Gawanda A. The Checklist Manifesto: How to Get Things Right. New York: Metropolitan Books, 2010.