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Drug administration errors: a prospective survey from three South African teaching hospitals

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SUMMARY

This prospective study was undertaken to determine the incidence of drug administration errors by anaesthetists at three tertiary South African hospitals. Hospitals A and C treat adults predominantly, whereas Hospital B is a paediatric hospital.

Anaesthetists completed an anonymous study form for every anaesthetic performed over a six-month period. They were asked to indicate whether or not an error or near-miss had occurred and if so, the details thereof.

A total of 30,412 anaesthetics were administered during the study period. The response rate and combined incidence of errors and near-misses was as follows: Hospital A 48.8% (1:320), B 81.3% (1:252) and C 48.1% (1:250). The overall response rate was 53% and the combined incidence was 1:274. Neither the experience of the anaesthetist nor emergency surgery influenced whether an error occurred or not. Most errors occurred during the maintenance phase of anaesthesia. The most common errors were those of substitution. At the paediatric hospital, incorrect dose was as frequent an error as substitution. Of all errors, 36.9% were due to drug ampoule misidentification; of these the majority (64.4%) were due to similar looking ampoules. Another 21.3% were due to syringe identification errors. No major complication attributable to a drug administration error was reported.

Despite an increasing awareness of the problem together with suggestions in the literature to reduce the incidence, drug administration errors remain fairly common in South Africa. Failure to institute suggested solutions will continue to compromise patient safety.

Key Words: drug administration, errors

Errors in medical practice are not uncommon and may contribute significantly to health care costs and result in harm to patients[1]. The risk of serious drug errors in anaesthesia may be higher than other specialties[2]. This is hardly surprising, considering that the average anaesthetist administers at least a quarter of a million drugs during a practice lifetime[3]. The reported incidence of drug error during anaesthesia varies considerably from 1:133 (0.75%) to 1:5475 (0.02%)[4-7]. Differences in study design and data collection may account for some of this discrepancy. Limited data exist for South Africa[8,9]. This prospective study was undertaken to determine the incidence of drug administration errors and near-misses at three tertiary-care hospitals in South Africa. Hospitals A and C had predominantly adult patients and Hospital B was a specialist paediatric hospital.

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MATERIALS AND METHODS

The study was approved by the Ethics Committees of the universities to which the hospitals were affiliated.

Anaesthetists were asked to complete a study form for every anaesthetic performed during a six-month period. They were asked to indicate whether a drug administration error or near-miss (an incident with

the potential to become an error) had occurred or not. If such an incident had occurred, they were asked to provide further details according to the questions on the form (see Appendix on the online version). All forms were completed anonymously.

Operating theatre registers were used to determine the number of anaesthetics performed during the study period. This was used to determine the denominator when calculating the incidence of errors, rather than the number of forms completed. Data were collected into an Excel spreadsheet and analysed using an Access database program and Statistica statistical package. Distributive data were analysed using the Chi-squared test using an alpha value of 0.05.

RESULTS

Data at Hospitals A and B were collected from the beginning of April 2005 to the end of September 2005. Collection of data from Hospital C was delayed as a result of waiting for Ethics Committee approval and was collected from July 2005 till January 2006. All anaesthetics were performed by physician anaesthetists (specialist anaesthesiologists and/or trainees).

A total of 30,412 anaesthetics were performed during the study period. Study forms were completed in 53% of anaesthetics. The individual hospital response rates were: Hospital A 48.8%, Hospital B 81.3% and Hospital C 48.1%.

TABLE 1
Errors and near-misses

Hospital	A	B	C	Combined
Near-misses	16	4	25	45
Errors	22	13	31	66
Total errors	38	17	56	111
Anaesthetics, n	12,155	4278	13,979	30,412
Response %	48.8	81.3	48.1	53.0
Incidence	1:320	1:252	1:250	1:274

Sixty-six errors and 45 near-misses were reported. The incidence of errors and near-misses combined at each hospital was Hospital A 1:320, B 1:252 and C 1:250 (Table 1). The overall incidence for the three hospitals was 1:274.

The experience of the anaesthetic provider was not a factor in determining whether an error would occur or not (Table 2).

Most of the errors occurred during the maintenance phase of anaesthesia (Table 3).

The types of errors and near-misses are shown in Table 4. More than half the errors (54%) were those of substitution; in Hospital B (the paediatric hospital), incorrect dose was as frequent an error as substitution. The drugs involved in the errors and near-misses are tabulated in Table 5. Muscle relaxants accounted for 25.3% of substitution errors, followed by opiates and vasoactive drugs with 13.4% each. Factors drawing the attention of the anaesthetic provider to the error or near-miss are indicated in Table 6.

TABLE 3
Timing of error

	Hospital A	Hospital B	Hospital C
Pre-induction	6	2	12
Induction	4	1	6
Maintenance	19	9	21
Reversal	4	1	7
Recovery	1	2	0

TABLE 4
Type of error

Type of error	Hospital A	Hospital B	Hospital C
Incorrect dose	10	6	10
Incorrect route	1	4	2
Substitution	22	6	39
Omission	2	0	2
Repetition	3	1	3

TABLE 2
Experience of anaesthetic provider (P=0.08, chi²)

Experience (years)	Hospital A error/cases n	Hospital B error/cases n	Hospital C error/cases n	Overall error/cases n	% error
<2	5/908	0/15	12/1590	17/2513	0.68
2-5	7/1516	1/936	20/2590	28/5042	0.56
6-10	10/2161	5/1281	10/815	25/4257	0.59
11-15	5/477	1/234	0/497	6/1208	0.50
>15	9/727	9/954	8/773	26/2454	1.06

TABLE 5
Drugs involved with the 111 errors and near-misses

Substitution (67)	Muscle relaxants (17), opiates (9), vasopressors (8), local anaesthetic agents (6), induction agents (3), oxytocics (3), fluids (4), other (17)		
Incorrect dose (26)	Volatiles (8), opiates (5), muscle relaxants (2), other (11)		
Repetition (7)	Muscle relaxant (2), opiate (1), antibiotic (1), ketamine (1), paracetamol (1), suppository (1)		
Omission (4)	Volatile agent (3), muscle relaxant (1)		
Incorrect route / site (7)		*Administered route*	*Intended route*
	Propofol	Intra-arterial	Intravenous
	Sodium bicarbonate	Intra-arterial	Intravenous
	Local anaesthetic	Intravenous	Epidural
	Local anaesthetic	Intravenous	Epidural
	Phenylephrine	Epidural	Intravenous
	Local anaesthetic	Left inguinal block	Right inguinal block
	Local anaesthetic	Inguinal block	Penile block

TABLE 6
Attention to error/near-miss drawn by:

	Hospital A		Hospital B		Hospital C	
	Errors	Near-misses	Errors	Near-misses	Errors	Near-misses
Clinical effects	8		3		10	
Label	2	3	2	2	10	6
Other clinician	6	4	5		3	5
Assistant		2			1	1
Other	4	3	2		4	2
Not stated	2	4	5	2	3	11

Drug ampoule misidentification accounted for 36.9% of errors. Of these errors, 64.4% were reported as being due to similar-looking ampoules. Syringe identification errors accounted for 21.3% of all errors.

Of the 66 errors, seven respondents (10.6%) reported being on medication at the time. Of these, four were on antiretroviral medication.

Although some of the immediate clinical effects of errors such as desaturation, apnoea and hypotension were potentially serious, all were treated rapidly and there were no longterm sequelae documented. Five errors (6.9%) resulted in anaesthesia being prolonged by more than 30 minutes, but no error resulted in anaesthesia being prolonged by more than 60 minutes.

TABLE 7
Errors during elective/emergency procedures

	Hospital A	Hospital B	Hospital C
Elective	19/3462	8/2277	19/2835
Emergency	13/2032	4/952	24/3218

There were no differences in the incidence of errors between elective and emergency cases (Table 7).

DISCUSSION

Retrospective surveys have shown that most anaesthetists will administer a wrong drug at some stage in their careers[8-11]. Data from such studies are incomplete and the absence of a denominator prevents calculation of the true incidence. In the absence of data from South Africa, we embarked on a prospective study to determine the actual incidence, nature of and causes of drug administration errors by anaesthetists in South Africa.

The strength of our study was that data were collected prospectively for a large number of anaesthetics at three institutions. The knowledge of the exact number of anaesthetics performed during the study period enabled us to calculate the minimum incidence of errors and near-misses. The combined incidence at the three hospitals was at least one in 274 anaesthetics (0.0037, 95% confidence intervals [CI] 0.0025 to 0.0049) and that of an actual

error being made was one in 460 anaesthetics (0.0024, 95% CI 0.0008 to 0.0039). This is less than the one in 133 reported by Webster et al[4], but more than the one in 909 reported by Fasting[5] and the one in 4943 reported by Hintong[7]. Like Webster et al, we adopted a conservative approach in using the number of anaesthetics rather than the number of forms returned in determining the denominator. Using the number of returned forms as the denominator, the actual error rate would be 1:245 anaesthetics (0.004, 95% CI 0.0028 to 0.0053).

While there are a number of published studies relating to errors in paediatric hospitals, to the best of our knowledge this is the first study giving an incidence of drug error in paediatric anaesthesia. The combined incidence for errors and near-misses in the paediatric hospital was one in 252, and the incidence of errors was one in 329. Unlike adult anaesthesia, drug dosage errors were as common as substitution errors. This is not surprising given the need for mass-related drug dosing, often requiring dilution of drugs. To decrease these errors, the mass of the patient and a calculator should be readily available in theatre. Extreme vigilance should be the order of the day when diluting drugs, i.e. check twice and with a colleague if possible.

Despite the increased awareness of the problem in recent years and recommendations to improve the safety of medication delivery systems in theatre for patients[12,13], our study confirms that drug administration errors are still quite common. On average there is one drug administration error per week at each of these hospitals and if errors are combined with near-misses, one and a half per week. In keeping with other studies we demonstrated that muscle relaxants were the most common agents involved in drug administration errors[7]. Red plunger syringes are not used at our hospitals.

Strategies to reduce the incidence of errors caused by syringe swaps include clear labelling of all syringes and the adoption of the uniform, international, colour-coded labelling system, as accepted in Australasia, Canada, the United Kingdom and the United States of America. The International Organization for Standardization and Standards South African (a division of South African Bureau of Standards) are currently developing local standards for user-applied labels on syringes in theatre. Critics of this system have argued that the use of colour-coded labels may lead to an increase in errors as practitioners may rely purely on the colour of the label rather than careful reading of the label. The use of colour-coded labels may not in itself reduce the risk of drug errors between drugs of the same class, but may limit the severity of an error. One study designed to ascertain whether colour-coded labels would reduce the incidence of drug errors was unable to demonstrate a benefit. The methodology and statistical analysis of this study[5], has been questioned[12]. For maximum efficiency, the appropriate colour labels need to be available in every operating theatre. In this study, Hospital A uses predominantly colour-coded labels. Syringes in Hospitals B and C are marked either with a marker pen or the name of the drug is written on a white label.

Ampoule misidentification was a major cause of substitution errors. This is a disappointing finding, given the fact that more than 10 years have elapsed since Orser and Oxorn advocated improvements in drug packaging[14]. There is an urgent need for an international standard for drug ampoule labelling. This should address font size, legibility and the use of generic names (rather than trade names) as the dominant feature on the label. An additional feature could be the use of colour-coded identifiers on labels to identify drug class. Other solutions include the use of a scanner to read bar-coded labels on ampoules prior to drawing up drugs[15] and pre-packaged syringes[16]. Extensive literature exists demonstrating that humans frequently use pattern recognition to identify words rather than reading the full text. This is particularly likely to happen when the particular word begins and ends with the same letter[17]. Anaesthetists and trainees therefore need to be taught to make a conscious effort to read the ampoule label prior to drawing up every drug.

Attention needs to be given to the way drugs are stored in the theatre environment. At present there is no uniform system for the anaesthetic workspace and drug drawers. Teaching new trainees in anaesthesia to be more systematic and methodical in their management of syringes, such as the system advocated by Merry et al[15], may complement the colour-coded labelling system and may further reduce errors.

In contrast to other studies, most of the errors occurred during the maintenance phase of anaesthesia rather than at induction[7,18]. This may be due to anaesthetists being more vigilant at the beginning and end of a case. Alternatively, this may simply be due to the fact that the maintenance phase represents the longest period of any anaesthetic.

The authors of the Thai Anesthesia Incidents Study were unable to demonstrate an increased incidence of drug errors in emergency cases compared with elective cases, as reported previously[7]. Our study supports their observation.

Although there was no statistical evidence that the experience of the anaesthetic provider was a factor in determining whether an error would occur or not, there was a suggestion of a higher incidence with very experienced anaesthetic providers (Table 3). This may be a case of becoming careless with increasing familiarity, being exposed to more complex cases, or simply feeling more comfortable with being honest and reporting errors.

It is interesting that of the seven respondents who admitted to being on medication while making an error, four were on antiretroviral agents. Given the high incidence of HIV infection in South Africa it is likely that a proportion of South African anaesthetists will be taking antiretroviral agents either for prophylaxis or therapy. From the personal experience of at least two authors, starting prophylactic antiretroviral agents is associated with anxiety-related stress and sleep disorders, particularly while awaiting results of possible seroconversion. There is thus a strong possibility that taking these drugs may impact on the performance of physicians. This may have implications when scheduling duties of anaesthetists who are taking antiretroviral medication. However, this study was not designed to assess either causes or effects of impaired performance and further studies in this area are warranted.

A weakness of this study is that it relied on voluntary reporting. Although the response rate from Hospital B was very good, the response rate from Hospitals A and C was below expectation. The requirement for anonymity limited the ability to intervene to improve the response rate. Even 100% response rate would underestimate the true incidence because of errors, and especially of near-misses, that pass unrecognised by the anaesthetist.

Anaesthetists need to be constantly aware of the risks of drug errors and should strive to limit errors through the measures identified. In addition, trainees in anaesthesia should be instructed in the systematic labelling and management of syringes in their daily practice. Where system problems have been identified and measures identified to reduce or eliminate them, such measures should be actively adopted[15].

National incident reporting systems allowing de-identified, anonymous reporting should be developed[19]. In the absence of such systems, institutions should develop their own critical incident monitoring system to identify key local causative factors and also serve as a reminder of the risks associated with the provision of anaesthesia.

As Merry et al have pointed out, the problem of drug administration error has been well described, but without the will to invest in solutions, patient safety remains at risk[19]. The onus to ensure patient safety is on all those concerned, namely anaesthetists, hospital administrators and drug manufacturers.

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