LESSON OF THE WEEK

Information technology cannot guarantee patient safety

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Human error and software inadequacy can combine to make drug doses calculated on handheld computers unreliable

Information technology tools, such as those used to calculate drug doses and infusion rates, can help reduce adverse events and prevent errors.¹ Drug dosages for children are usually calculated on the basis of weight. Calculations are especially prone to error and delay in crisis situations such as resuscitation. In such settings, computer based tools may improve clinical care, although human error can still occur, as illustrated by this case report.

Case report

A 3 month old infant who arrived at the emergency department of a small regional hospital had clinical signs of meningococcal sepsis with petechiae, purpura, and shock. The infant was subsequently transferred to our paediatric intensive care unit. During transfer the patient was given infusions of dobutamine and noradrenaline by the transferring intensivist. The concentrations of 12 drugs that might be needed for infusion during transport had previously been calculated in the intensive care unit by the resident. This had been done by entering the patient's weight into a preprogrammed PocketExcel sheet for a personal digital assistant (handheld computer).

When the patient arrived at the unit all running drugs were ordered using our electronic patient data management system (a bedside computer application). This system uses the patient's weight and the desired infusion rate to calculate concentrations of solutions for infusion. However, the concentration of noradrenaline calculated was sevenfold lower than that calculated previously, so that the patient had received a sevenfold higher dose of this drug than intended for at least two hours.

Discussion

The doctor's point of view

The discrepancy between the doses of noradrenaline calculated by the two methods was unexpected, as we had not had problems with the PocketExcel sheet before. On investigation, we found that the "formulae cells" of the PocketExcel sheet cannot be locked, and that in this case the concentration of noradrenaline for infusion had mistakenly been overwritten by the patient's weight (figure). This mistake should have been noticed as the weight had to be typed in twice, but a combination of fatigue (four o'clock in the morning)

Microsoft Excel - resuscitation.xls

	A	B	C	D
1	Weight (kg)	Dose	unit	dose/kg
2	4.5			
3	Epineprine (1:10000)	0.45 ml		IV 0.01 mg/kg
4	Atropine 1ml=5mg	1 ml		0.02 mg/kg=0.0
5	Defibrillation	9 Joules		2J/kg, 2J/kg, 4
6	Dopamine	32.4 mg/24ml		5ug/kg/min
7	Dobutamine	32.4 mg/24ml		5ug/kg/min
8	Norepinephrine	0.65 mg/24ml		0.1 ug/kg/min
9	NaBic 4.2%	9 ml		2 ml/kg
10	Ca Sandoz	2.25 ml		0.5 ml/kg
11	Glucose 20%	4.5 ml		1-2 ml/kg
12	Midazolam	0.45 mg		0.1mg/kg iv
13		2.25 mg		0.5mg/kg recta
14		10.8 mg/24ml		0.1 mg/kg/h iv
15	Phenytoin	90 mg		20 mg/kg
16	Phenobarbital	90 mg		20 mg/kg
17				

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6	Dopamine	32.4 mg/24ml		5ug/kg/min
7	Dobutamine	32.4 mg/24ml		5ug/kg/min
8	Norepinephrine	4.50 mg/24ml		0.1 ug/kg/min
9	NaBic 4.2%	9 ml		2 ml/kg
10	Ca Sandoz	2.25 ml		0.5 ml/kg
11	Glucose 20%	4.5 ml		1-2 ml/kg
12	Midazolam	0.45 mg		0.1mg/kg iv
13		2.25 mg		0.5mg/kg recta
14		10.8 mg/24ml		0.1 mg/kg/h iv
15	Phenytoin	90 mg		20 mg/kg
16	Phenobarbital	90 mg		20 mg/kg
17				

PocketExcel sheet for calculating drug doses. The top panel shows the correct calculation of the dose of noradrenaline (norepinephrine) for infusion into a patient weighing 4.5 kg. The blue arrow indicates the formula used to calculate the dose. The red arrow indicates the concentration needed to achieve 0.1 µg/kg/min at a rate of 1 ml/h. The bottom panel shows how a mistake was made in the calculation. The formula has been displaced by the weight of the patient (4.5; blue arrow) and the resulting dose is wrong (red arrow)

and stress probably meant that it was overlooked. Furthermore, the doses were not double checked.

Because the risk of making a mistake when calculating drug dosages increases in crisis situations, a paediatric resuscitation chart was introduced in 1986.² On this printed chart, which is used in emergency departments and intensive care units, drug dosages are pre-calculated for each kilogram of body weight.

As early as 1982, a program was developed for use with programmable scientific calculators that could calculate concentrations of continuous drug infusions in paediatric patients in intensive care.^{3,4} More recently, doses of drugs for resuscitation have been calculated by using software programs written in languages such as Visual Basic or C and spreadsheet programs such as Excel. No official program is available in our paediatric intensive care unit for calculating doses and infusion rates of resuscitation drugs. A paper form is used instead, and the dose and infusion rate of 12 drugs must be calculated individually for each new admission. However, residents have been using an unofficial PocketExcel spreadsheet to help with these time consuming calculations.

Although computer programs can be used to calculate drug concentrations, this case shows that human error is not necessarily eliminated. Pre-printed resuscitation charts abolish the need for calculations and may be safer than computer based calculators. However, given the range of weights and doses in paediatrics, several charts are needed in children, and this also increases the risk for human error. This case highlights the importance of the doctor and a colleague double checking such calculations, a requirement that is common practice in the nursing profession.

The information technology specialist's point of view

In the desktop version of Excel cells can be locked to prevent loss or mistyping of formulae. However, this option is not available in the version of Excel used for handheld computers (PocketExcel). Moreover, the formula options for PocketExcel do not permit automatic minimum and maximum doses. Warnings about minimum or maximum doses can easily be missed without scrolling up and down. These shortcomings have led to the emergence of other spreadsheet programs for handheld computers. Visual Basic programs are available for handheld computers, but unlike PocketExcel, which is user friendly and easy to navigate, more than average knowledge about computers is needed to use such programs.

In the second half of the 1980s (after the introduction of personal computers), in many businesses employees developed their own applications using spreadsheets.

People took advantage of the new tools because the usual process of software development was slow and often did not do what was intended.⁵ This can be a risky approach, however, as shown by our case report. Commercial software is tested rigorously during development. With homemade spreadsheets, calculations may simply be wrong or incomplete, and control over the data may be lost, possibly with serious consequences for the patient. This problem is not unique to medicine. The European Spreadsheet Risks Interest Group publishes reports of spreadsheet errors that include a quantified error or documented impact.⁶

Organisations should control the development of these programs and ensure the quality of any programs that are used. In the 1980s, this led to the implementation of "information centres," which provide support, training, and guidelines for end users. Hospitals may again choose to support doctors in this way. Medical associations could use the latest insights in their field to make properly tested and ready to use software available to their members. However, this approach may not be feasible because of a lack of time and resources. Hence, as handheld computers are increasingly being used for important calculations, hospitals should at least increase awareness of the possible pitfalls.

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- 1 Bates DW, Gawande AA. Improving safety with information technology. *N Engl J Med* 2003;348:2526-34.
- 2 Luten RC. Pediatric resuscitation chart and equipment shelf: aids to mastery of age-related problems. *J Emerg Med* 1986;4:9-14.
- 3 Melzer-Lange M, Wyatt D, Walsh-Kelly C, Smith D, Hegenbarth MA, Eisenberg CS. Improved speed and accuracy of calculations with a programmable calculator in pediatric emergency scenarios. *Am J Dis Child* 1991;145:264-6.
- 4 Neu J, Mahoney C, Wilson AD, Rice TB. Calculator assisted determination of dilutions for continuous infusion ICU medications. *Crit Care Med* 1982;10:610-2.
- 5 Laudon KC, Laudon JP. Approaches to systems-building. In: Cox M, ed. *Management information systems. Organization and technology in the networked enterprise*. Upper Saddle River, NJ: Prentice Hall, 2000:377-80.
- 6 European Spreadsheet Risks Interest Group. *Spreadsheet mistakes—news stories*. 2006. www.eusprig.org/stories.htm.

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What's in a name?

A woman presented to the tuberculosis clinic in Cape Town with persistent cough and weight loss. At the start of the consultation I asked her whether she was employed, and she replied that she was a prostitute.

My inquiry as to her condom use provoked a somewhat shocked reaction and disbelief that I should want to know such information. Explaining that her work put her at increased risk of acquiring HIV infection and other sexually transmitted diseases, I was perplexed by her open mouth and incredulous expression.

Realising that something was wrong, I asked her again what her profession was. "A prosecutor," she replied.

Luckily, her field of expertise lay outside the medicolegal sphere, and she was able to see the funny side. However, the old adage runs true: always listen to your patient to avoid mistakes.

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