

Citation for published version:

John Talbot and James Coulson, 'The effect of a targeted clinical toxicology training intervention on the diagnostic accuracy and management of paramedics exposed to clinical simulation: a repeated measures study', *British Paramedic Journal*, 2016, Vol. 1 (1): 15-25

Link to the published version:

<https://britishparamedicjournal.co.uk/vol1issue1art3>

Document Version:

This is the Published Version.

Copyright and Reuse:

© The Author(s) 2016.

Content in the UH Research Archive is made available for personal research or study, educational or non-commercial purposes only. Content is protected by copyright, permissions for further reuse of content should be sought from the publisher, author or other copyright holder.

Enquiries

If you believe this document infringes copyright, please contact the Research & Scholarly Communications Team at rsc@herts.ac.uk

Original research

The effect of a targeted clinical toxicology training intervention on the diagnostic accuracy and management of paramedics exposed to clinical simulation: a repeated measures study

John Talbot*

University of Hertfordshire
j.r.talbot2@herts.ac.uk

James Coulson

National Poisons Information Service (Cardiff)

British Paramedic Journal
2016, vol. 1(1) 15–25
© The Author(s) 2016
ISSN 1478-4726
Reprints and permissions:
info@class.co.uk



OPEN ACCESS

The BPJ is the journal of the
College of Paramedics:
www.collegeofparamedics.co.uk

Abstract

Background – As first contact practitioners in a variety of medical emergencies, paramedics are frequently required to manage a number of toxicological emergencies. Although mortality from poisonings is low, timely and appropriate management can help to prevent subsequent sequelae such as acute coronary syndromes in cocaine toxicity, dangerous arrhythmias after tricyclic antidepressant overdose and regurgitation of gastric content following opioid poisoning. Paramedics potentially have underdeveloped knowledge of toxic syndromes (toxidromes), instead relying on heuristics and experience to manage poisoning emergencies. Moreover formal teaching of pharmacology and toxicology on paramedic undergraduate programmes is not universal, potentially leading to suboptimal management of poisoned patients.

Study objectives – To evaluate baseline diagnostic accuracy and management of poisoning emergencies by undergraduate paramedics and the effect of participation in a targeted toxicological training intervention on diagnostic accuracy and management among undergraduate paramedics when assessed through clinical simulation.

Methods – The research utilised a two-stage repeated measures design; following completion of a Likert scale questionnaire a cohort of final year undergraduate paramedics from the University of Northamptonshire undertook three 5-minute simulated patient scenarios on a Laerdal SimMan® programmed to display specific clinical signs; a written sheet with a brief history accompanied each scenario. The scenarios were designed to reflect current paramedic practice comprising opioid (scenario 1), tricyclic antidepressant (scenario 2) and beta blocker overdoses (scenario 3). Two weeks after completing the scenarios the cohort attended a targeted 90-minute educational intervention; a further two months later the cohort repeated the scenarios although the order in which the individual cases were encountered was changed.

* **Corresponding author:**

John Talbot, Paramedic Research Fellow, University of Hertfordshire, College Lane Hatfield, Hatfield AL10 9EU, UK.

Results – Twenty-one participants were enrolled on the study of which 20 completed both stages of testing. All three scenarios demonstrated statistically significant improvements in the number of participants diagnosing all three scenarios correctly, 25.4% versus 95% ($p < 0.001$). Diagnostic synthesis was also shown to improve to statistically significant levels following the educational intervention in scenarios 1 and 2 ($p = 0.004$) and ($p < 0.001$) respectively; a situation repeated in scenarios 1 and 2 when comparing treatment interventions ($p = 0.004$) and ($p < 0.001$). Analysis of the Likert responses pre- and post-intervention demonstrated a statistically significant change towards agreement; question 2 ($p = 0.012$) question 3 ($p < 0.001$) question 4 ($p = 0.002$) question 5 ($p = 0.005$).

Conclusion – Participation in a targeted toxicological training intervention improves self-reported confidence of participants in recognising and managing poisoning incidents. Furthermore diagnostic accuracy, synthesis and subsequent treatment provision was also improved when assessed by clinical simulation.

Keywords

paramedics; toxicology; education

Introduction

As first contact practitioners in a variety of medical emergencies, paramedics are frequently required to manage a number of toxicological emergencies. Although overall mortality from poisonings is low, timely and appropriate management can help prevent subsequent sequelae such as acute coronary syndromes in cocaine toxicity, regurgitation of gastric contents and respiratory depression following opioid poisoning and dangerous arrhythmias after tricyclic antidepressant overdose (Greene, Dargan, & Jones, 2005; Hassan, Pickett, Durham, & Barker, 1996).

Unlike emergency departments the pre-hospital environment lacks the biochemical testing infrastructure available to emergency department physicians such as arterial blood gases (ABG), urea and electrolytes (U&Es) and chest X-rays. As a consequence paramedics are heavily reliant on the presenting physical findings and information from basic observations such as temperature, pulse, blood pressure and electrocardiograms (ECGs) which must be interpreted within the context of an unfolding poisoning emergency.

Toxicological emergencies in the pre-hospital setting encompass a broad range of acute and sub-acute emergencies, ranging from accidental poisonings, drug overdoses, therapeutic excess, environmental and occupational poisonings and recreational drug emergencies (Greene et al., 2005).

Groups of signs and symptoms in poisonings are often referred to as the toxic syndrome or toxidrome; these clinical manifestations may present as a particular ECG tracing, dermatological signs such as sweating, pupillary signs for example pinpoint pupils in opioid poisoning. Toxidromes form a characteristic pattern and as such represent a form of diagnostic reasoning akin to pattern recognition (Mofenson & Caraccio, 1985).

Clinical decision making (CDM) also called diagnostic reasoning (DR) is a complex process involving several distinctive clinical and cognitive domains; the acquisition of data (clinical signs and symptoms) is typically used to formulate several hypotheses which are in turn tested and subsequently accepted or rejected based on the available data; often referred to as hypothetico-deductive or backward reasoning, this process can be slow and inefficient (Bowen, 2006; Croskerry, 2002). Expert CDM is thought to utilise forward reasoning in which the available data are compared to previous cases stored as illness scripts. These scripts typically comprise three domains: predisposing factors, pathological insult and clinical consequences. Often referred to as pattern recognition, this cognitive process requires many years of clinical practice to master and is therefore rarely used by clinical novices (Fleming, Cutrer, Reimschisel, & Gigante, 2012).

Examination of the CDM processes of paramedics in comparison to emergency care practitioners (paramedics with extended scope training and education) revealed the former tended to display a bounded approach with decision making limited to immediate treatment interventions and transport decisions, whereas the latter demonstrated a more structured diagnostic strategy, where a diagnosis was achieved as an endpoint following history taking and examination (Halter & Marlow, 2005). This notwithstanding, recognition of clusters of signs and symptoms which is the hallmark of pattern recognition can be deployed by paramedics and toxidromes are one such area potentially amenable to this strategy (Jensen, Croskerry, & Travers, 2009).

Methods

The research utilised a two-stage repeated measures experimental (within subjects) design, between January and April 2015. The PubMed, CINAHL and emergency

Table 1. Clinical findings opioid toxicity

Clinical finding	Predictive	Comments
Deep coma	++	Seen in several toxidromes
Hypotonia	+	Demonstrates CNS depression
Hyporeflexia	+	Demonstrates CNS depression
Sedation	++++	Highly predictive
Bradypnoea	++++	Highly predictive
Apnoea	++++	Highly predictive
Miosis	++++	Highly predictive
Hypotension	+	Seen in TCA and other toxidromes
Hypothermia	+	Usually a secondary finding
Absent bowel sounds	+	Seen in anticholinergic toxidrome
Bradycardia	+	Seen in poisonings with cardiac drugs/cholinergic toxidrome/not seen commonly in case report evidence
Compartment syndrome	+	Usually a secondary finding
Rhabdomyolysis	+	Usually a secondary finding
ARF	+	Usually a secondary finding
Fentanyl patches	++++	Highly predictive if discovered on examination
Pharmacodynamic response	++++	Highly predictive naloxone response

medicine journal electronic database were searched during the month of December 2014 using the following key words to access relevant literature: *toxicology, poisoning, pre-hospital, paramedic, EMS, training, education, drug overdose, opioids, beta blockers, cardiac drugs, tricyclic antidepressants, simulation*. No similar studies were identified.

Design of the toxicology scenarios

Individual scenarios were developed in conjunction with an expert panel comprising a consultant paramedic, anaesthetist and a paramedic educational programme lead. Participants were deemed to have attended as a single responder (car based paramedic) and therefore would have to gather the relevant physiological data before proceeding onto any management. The scenarios included a male patient poisoned with opioids, a female poisoned with a tricyclic antidepressant and an elderly female poisoned with beta blockers. The scenarios were designed to represent realistic patient encounters with

agents that could respond to basic support measures in the case of tricyclics, as well as the use of an antidote in the case of opioids (naloxone) and beta blockers (atropine) (Clarke, Dargan, & Jones, 2005; Kerns, 2007).

Scenario 1 (Table 1) represented an opioid poisoned male; the mannequin was programmed with pinpoint pupils, reduced respiration frequency (six breaths per minute) and oxygen saturations of 90%; as potential disagreement has been reported in assessment of mental status when using the Glasgow Coma Scale (GCS), a decision was made to utilise the 'alert, voice, pain, unresponsive' (AVPU) score across all three scenarios; this has been shown to correlate with GCS scores of (15) (13) (8) and (3) respectively and provides a simple and quick method to assess levels of consciousness (Kelly, Upex, & Bateman, 2004). An ECG showing normal sinus rhythm was also supplied. All three scenarios were presented with a blood glucose consistent with a normal homeostatic set point (Newsholme & Leech, 2009).

Scenario 2 (Table 2) represented a tricyclic overdose; the mannequin was set to indicate a tachycardia of

Table 2. Clinical findings tricyclic antidepressant toxicity.

Clinical finding	Predictive	Comments
Seizures	++	Seen in several toxidromes
Coma	++	Seen in several toxidromes
Absent bowel sounds	++	Anticholinergic effect
QRS widening	++++	Seen in certain β blockers/predictive
R/S ratio > 0.7	++++	Highly predictive in this context
Tachycardia	++	Seen in sympathomimetic toxidrome
Hypotension	+++	Highly predictive with tachycardia
Dry mouth	+++	Anticholinergic effect
Blurred vision	+++	Anticholinergic effect
Dilated pupils	++	Anticholinergic effect/sympathomimetics
Hyperthermia	++	Seen in NMS/serotonin toxicity/sympathomimetics
Dry skin	++	Anticholinergic effect
Urinary retention	+	Anticholinergic effect

Table 3. Clinical findings beta blocker toxicity.

Clinical finding	Predicative	Comments
Bradycardia	++++	Highly predictive for cardiac drugs
Hypotension	++++	Highly predictive for cardiac drugs
Cardiogenic shock	+++	Late finding in several toxidromes/predicative
Bronchospasm	+	Rare finding
Hypoglycaemia	+	Rare finding
Hyperglycaemia	+	Seen in CCB poisoning/discriminating feature
Seizures	++	Seen in several toxidromes
Coma	++	Seen in several toxidromes
Heart block	+++	Predictive for cardiac drugs
QRS widening	+++	Seen in TCA OD/certain β blockers

140 beats per minute and a blood pressure of 80/40. The supplied ECG showed a widened QRS and a positive R wave deflection in aVR in concordance with the published literature (Yates & Manini, 2012). The patient was described as dry, hot and flushed with a temperature of 37.5°C. The mannequin was also set with absent bowel sounds to provide an additional diagnostic clue should they be sought (Kerr, McGuffie, & Wilkie, 2001).

Scenario 3 (Table 3) represented a beta blocker poisoning; the mannequin was set to present with an absolute bradycardia (28 beats per minute) with corresponding hypotension (70/40); a supplied ECG showed bradycardia with first-degree heart block (Shepherd, 2006). The reduced level of consciousness was designed to indicate a highly lipid soluble beta blocker consistent with a supplied history indicating the patient was being managed by her GP for anxiety (Kerns, 2007).

A scoring system was developed for each scenario to allow for pre- and post-analysis of participant performance across all three scenarios. The system separated the scenarios into three categories: diagnosis either correct or not correct (dichotomous data), diagnostic synthesis, an amalgam of the three features selected by each participant and management, again an amalgam of the three interventions indicated by each participant. The scoring system employed positive one (+1) for each positive feature or intervention, a zero (0) for what was considered a neutral feature/intervention and a minus one (-1) for features that could have led to misdiagnosis/mismanagement and in the case of interventions may have been detrimental to the patient.

Furthermore, certain features and interventions were deemed highly significant and as such were awarded an additional positive one (+1); thus the use of naloxone in opioid toxicity and atropine in beta blocker poisoning were considered +2. Capturing the ECG features was considered of paramount importance in tricyclic poisoning and therefore tachycardia was awarded +1, ECG changes +2 and ECG specific such as widened QRS or positive 'R' wave in aVR was considered +3. The scoring system allowed the researcher to ascertain the effectiveness of the targeted educational intervention as certain

features and interventions could be aligned to the learning outcomes set out at the start of the research and should therefore be indicated with greater frequency in the post-intervention phase of testing (Lockey, 2001; Prideaux & Bligh, 2002).

Participants

A purposive sample of final year undergraduate paramedics (n = 21) from the University of Northampton. The programme of study is academically challenging, spanning two years and encompassing anatomy and physiology, biosciences, clinical care and pharmacology; in addition to classroom based studies, the students spend 750 hours per year in clinical practice (inclusive of in-hospital placements). A priori power calculations using G*Power calculation indicated a minimum sample size of 18 would be required. This concurs with similar studies involving paramedics diagnosing heart failure and ST segment changes in myocardial infarction (Edwards, 2011; Whitbread, Leah, Bell, & Coats, 2002).

Procedure

Electronic class records were used to identify potential participants who were advised by email message of the researcher's intention to address the class at the beginning of a pre-determined lecture. Potential participants were provided with study information sheets and consent forms.

Participants were asked to complete the consent forms and place them in a sealed envelope; the envelopes were collected by a member of the University of Northampton School of Health administration team. The administrator then entered the participant data into an Excel® (Microsoft Corporation USA) password protected database and using the RAND function, randomly allocated an anonymity number between 1 and 100. The anonymised database was then emailed to the researcher and was also held on a password protected computer; of the (n = 24) students who were approached (n = 21) agreed to participate in the research.

Initial data were collected by means of a questionnaire (Supplementary 1) which asked for simple demographic

data followed by five questions in which participants were asked to indicate agreement with a series of statements related to poisoned patients:

- Q1. In clinical practice I encounter patients who are either intentionally or accidentally poisoned by specific drugs or other agents.
- Q2. I am confident in my ability to identify what drug or other agent was used when attending poisoned patients.
- Q3. I am confident in my ability to relate vital signs (pulse, blood pressure) to poisonings by specific drugs or other agents.
- Q4. I am confident in my ability to interpret ECG findings in relation to poisonings by specific drugs or other agents.
- Q5. I am confident in my ability to manage poisoned patients using interventions currently available to paramedics.

Following collection of the questionnaire data, the participants were asked to complete three clinical scenarios; the scenarios were carried out in the University of Northampton paramedic skills laboratory using three standardised SimMan® mannequins (Laerdal Medical Corporation, TX, USA).

The scenarios were limited to five minutes' duration in which the participants were asked to perform an examination and write their preferred diagnosis followed by three features that led them to that diagnosis based on perceived order of importance; finally, the participants were asked to list three treatments or interventions that they would perform, again based on perceived order of importance. Blood glucose, ECG, AVPU, temperature and blood pressures were provided to ensure parity between participants.

Two weeks after completing the scenarios the participant attended a specifically designed, targeted 90-minute educational intervention. The intervention included an overview of the three classes of drugs involved in the poisonings, their mechanism of action and how this in turn relates to physical findings pertinent to each toxidrome. Following a two-month washout period the participants completed the questionnaire and scenarios again; the order of the scenarios was on this occasion changed in order to limit carry over effects and case spotting (Bowling, 2009).

Ethics

Ethical approval for the study was granted by the University of Northampton's Research Ethics Committee.

Data analysis

Data were analysed using the Statistical package for the Social Sciences (SPSS) (Version 22) (SPSS Incorporated, Chicago, IL, USA); due to the small size and relative homogeneity of the sample it was anticipated that an

abnormal distribution would result and as such non-parametric statistics would most likely be required; to ensure correct data analysis a test of normality was undertaken using the Shapiro-Wilk test; all the variables were non-normally distributed ($p < 0.001$) hence non-parametric tests were used for all inferential statistics (Greenhalgh, 2010).

Results

The study enrolled 21 participants, who all completed stage 1 of the study and attended the educational intervention. One participant did not attend stage 2 of the study. Initial breakdown of the participants showed that 66.6% ($n = 14$) were female, 85.7% ($n = 18$) were aged between 20 and 29; with 14.3% ($n = 3$) aged less than 20 years old. Of the 21 participants 90.4% ($n = 19$) were educated to A-level/BTEC or NVQ level 3 prior to commencing the foundation degree programme Paramedic Science (FdSc) in 2013, one participant commenced the programme having already completed a Bachelor's degree.

Pre- and post-intervention Likert scale responses are indicated in Figures 1 and 2 respectively. Analysis of the Likert responses pre- and post-intervention was conducted using the Wilcoxon signed ranks test and demonstrated a statistically significant change towards agreement; question 2 ($Z = 2.504$, $p = 0.012$), question 3 ($Z = 3.557$, $p < 0.001$), question 4 ($Z = 3.127$, $p = 0.002$), question 5 ($Z = 2.828$, $p = 0.005$). The responses to question 1 were close to evenly split: ($n = 11$) weekly, ($n = 12$) monthly. No other responses were recorded. Pre-intervention, male participants tended to indicate agreement with statements compared to females (46.2% versus 30%) in relation to questions 2–4, furthermore female participants were more likely to disagree with statements (70% versus 53.8%) ($\chi(1) = 0.888$, $p = 0.346$).

Figure 3 indicates an overall improvement for all three scenarios in diagnostic accuracy from 25.4% (17/63) to 95% (57/60) post-intervention, a change of 69.6%. An exact McNemar showed a statistically significant difference in the proportion of participants diagnosing all three scenarios correctly ($p < 0.001$). Analysis of pre- and post-diagnostic accuracy using Pearson's Chi squared showed no statistically significant difference in relation to gender; pre-test ($p = 0.682$), post-test ($p = 0.192$).

Figure 4, Box and Whisker plot 1 (diagnostic synthesis) demonstrates that the median score has increased from 2 to 3, the range has reduced from 5 to 4, and the IQ range score has also reduced from 2 to 0 indicating that greater than 50% scored 3. A Wilcoxon signed rank test showed that there is a statistically significant change elicited by the intervention ($Z = 4.790$, $p < 0.001$). The Cohen's effect was calculated at $r = 0.44$ implying a medium effect of the educational intervention. Analysis in respect of gender pre- and post-intervention using the Mann-Whitney U test indicated no statistically significant differences in performance relating to diagnostic

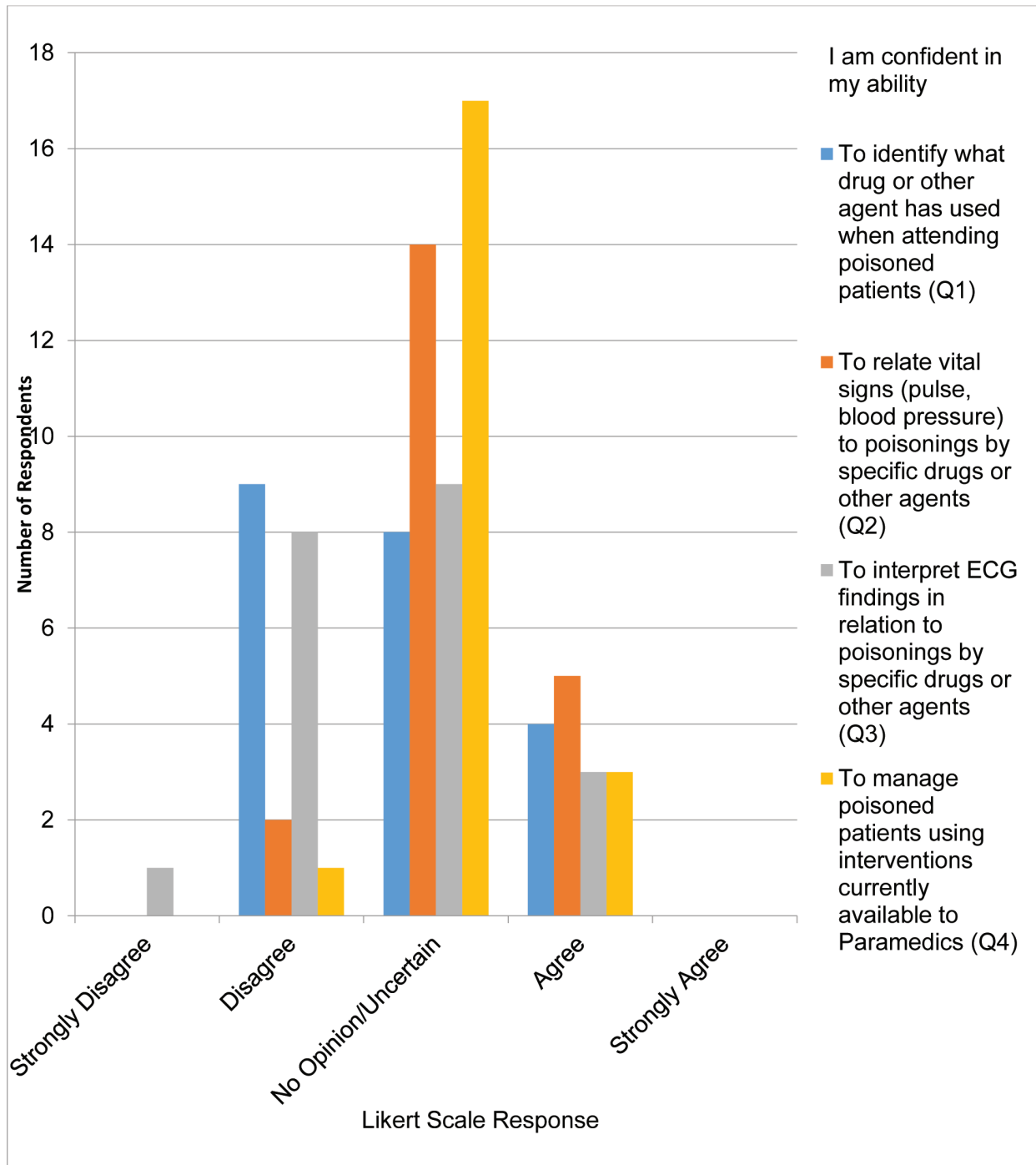


Figure 1. Likert scale responses pre-intervention.

synthesis pre-test ($U = 386, p = 0.401$) and post-test ($U = 399, p = 0.854$).

Figure 5, Box and Whisker plot 2 (treatment interventions) shows that the median (heavy black horizontal line) score has increased from 1 to 3 and the range has reduced from 5 to 4, and the interquartile range has also been reduced from 2 to 1. A Wilcoxon signed rank test showed that there is a statistically significant change elicited by the intervention ($Z = 4.677, p < 0.001$). The Cohen's effect was calculated at $r = 0.43$ implying a medium effect of the educational intervention. Analysis in respect of gender pre- and post-intervention using

the Mann-Whitney U test indicated no statistically significant differences in performance relating to treatment interventions pre-test ($U = 433, p = 0.904$) and post-test ($U = 368.5, p = 0.504$).

Discussion

The purpose of the study was to establish whether a targeted educational intervention could improve the diagnostic accuracy of paramedics, diagnosing and managing three toxicological emergencies assessed by clinical simulation.

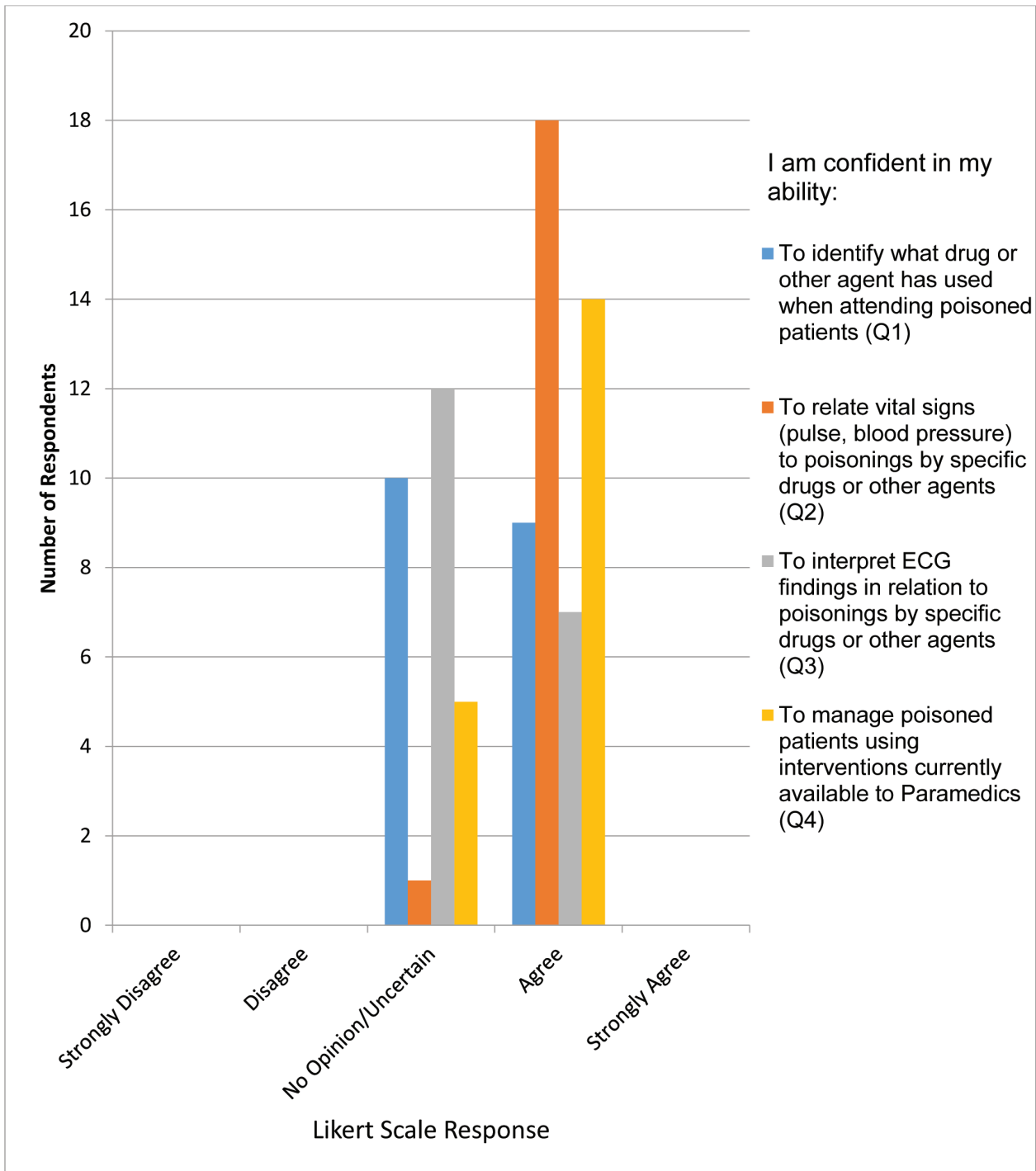


Figure 2. Likert scale responses post-intervention.

Methodological considerations concern the use of purposive (non-probability) sampling for the study; literature searching found that comparative studies measuring the effects of educational or training interventions on paramedics tended to use non-probability sampling (Frendl, Strauss, Underhill, & Goldstein, 2009; Siriwardena, Iqbal, Banerjee, Spaight, & Stephenson, 2009; Whitbread et al., 2002). The small sample size (n = 21) was chosen on the basis of accessibility and the limitations of time and facilities placed on the research which would have made a larger probability sample unrealistic (Peat, 2002).

The questionnaire results demonstrated a trend towards increasing confidence in identifying and managing poisoning incidents. Although the validity of the questionnaire may have been affected by social desirability responding (SDR) whereby participants may have responded more favourably post-intervention to please the researcher, what is often described as ‘faking good’, SDR is thought to manifest when questions are considered sensitive to the population under study, insofar as the participants may have chosen to respond positively post-intervention in order to demonstrate their competence

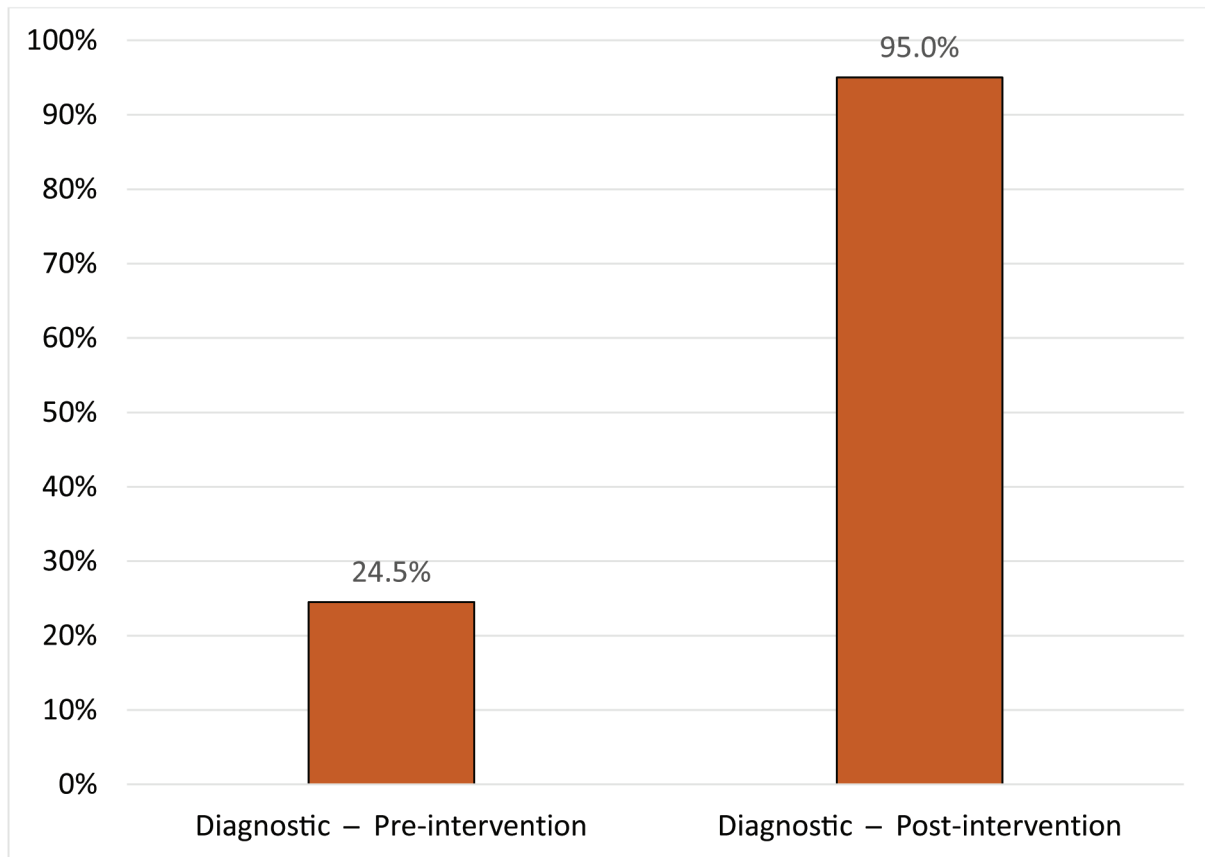


Figure 3. Pre- and post-intervention diagnostic accuracy all three scenarios.

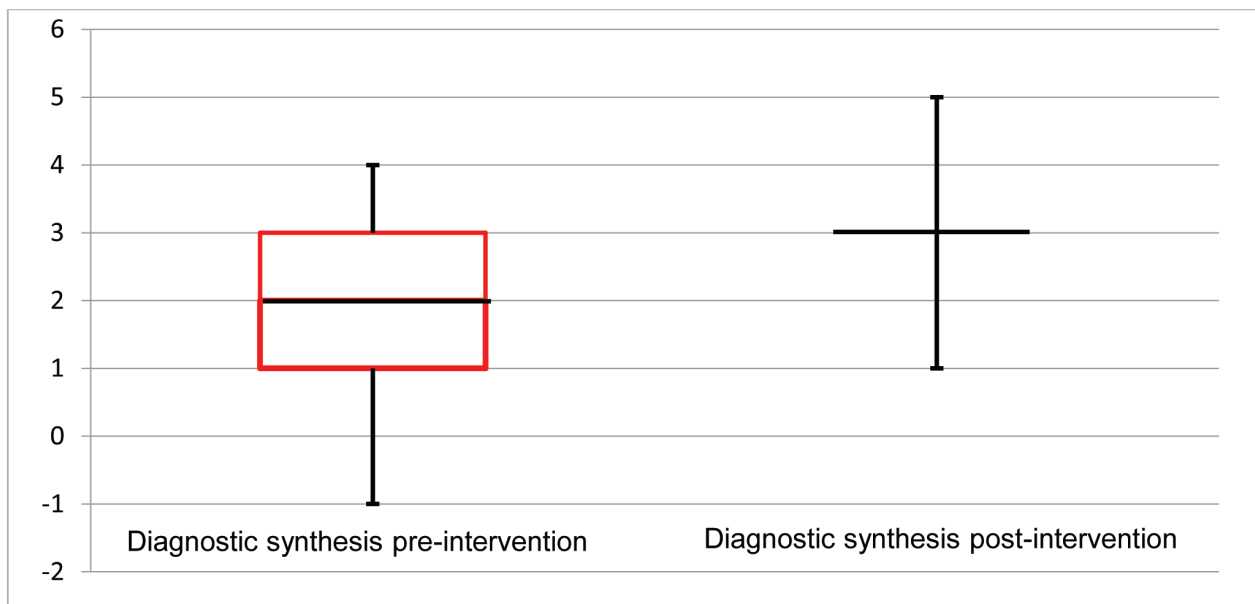


Figure 4. Box and whisker plot I showing diagnostic synthesis pre- and post-intervention for all three scenarios.

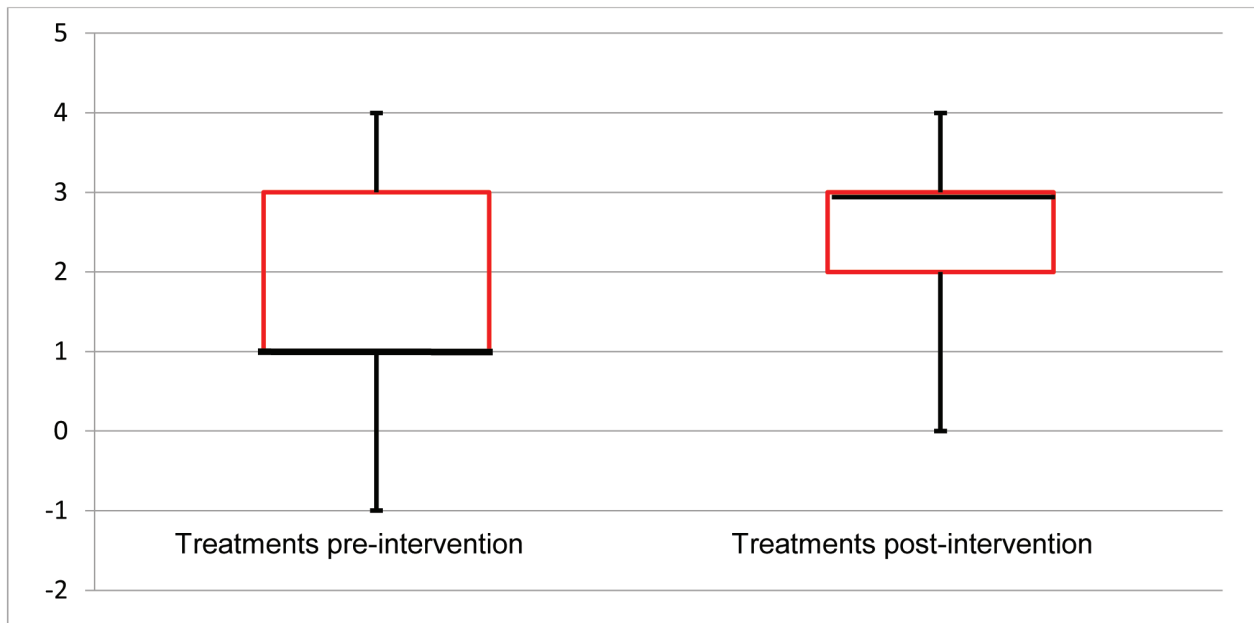


Figure 5. Box and whisker plot 2 showing treatments pre- and post-intervention for all three scenarios.

as paramedics having received the educational intervention (Parahoo, 2006); furthermore the participants may, having completed phase one of the research, become more confident in achieving higher levels of performance in phase 2; that is they had become 'test savvy' and were therefore comfortable with indicating improved levels of confidence.

All three scenarios demonstrated statistically significant improvements in the number of participants diagnosing all three scenarios correctly ($p < 0.001$). Diagnostic synthesis was also shown to improve to statistically significant levels following the educational intervention in scenarios 1 and 2 ($p = 0.004$) and ($p < 0.001$) respectively, a situation repeated in scenarios 1 and 2 when comparing treatment interventions ($p = 0.004$) and ($p < 0.001$). Although scenario 3 failed to reach statistical significance in diagnostic synthesis ($p = 0.84$) and treatment interventions ($p = .184$), overall improvements were still achieved insofar as an additional ($n = 11$) patients would have received atropine ($n = 16$) and only ($n = 1$) patient received an intervention that was considered detrimental versus ($n = 2$) in the pre-intervention phase of testing.

Additional improvements in clinical management were also observed post-intervention in scenario 1 with an additional ($n = 4$) patients receiving BVM ventilation moving the total from ($n = 8$) to ($n = 12$) which evidence – albeit from animal data – suggests potentially reduces the risk of heroin induced non-cardiogenic pulmonary oedema if delivered prior to naloxone reversal (Sterrett, Brownfield, Korn, Hollinger, & Henderson, 2003). Furthermore an additional ($n = 10$) patients would have received naloxone ($n = 17$) versus ($n = 7$) pre-intervention; these were both included in the educational content given to the participants. Moreover the educational components relating to toxidromes appear to have

made improvements in diagnostic synthesis with all but four participants indicating the classic triad of depressed respirations, sedation and miosis post-intervention in scenario 1; furthermore warm, dry skin ($n = 12$) and specific ECG changes such as positive R wave in aVR ($n = 9$) were indicated in scenario 2 post-intervention as part of the diagnostic synthesis, which was not indicated in pre-intervention testing and again formed part of the educational intervention. There is currently no directly comparable trial by which to judge the results of this study, however the trends compare favourably with similar research (Edwards, 2011; Whitbread et al., 2002).

The improvement in post-intervention diagnosis, diagnostic synthesis and treatment may potentially be explained by reactivity; reactivity describes the changed behaviour displayed by subjects because they are under study leading to improved or declining performance. One such phenomenon is the Hawthorne effect; initially used to describe the relationship between improved productivity and observation in the workshops of the Chicago based Western Electrical Company between 1927 and 1932, it has been widely applied in many fields of research to demonstrate the link between participant performance and direct or perceived observation (Hansson & Wigblad, 2006).

The decision to use clinical simulation primarily rested on its reproducibility which allowed each participant to be exposed to exactly the same presentation on both occasions in keeping with the ideology of the repeated measures design; despite changing the order in which the scenarios were presented, it is possible that participant performance improved by case spotting in the post-intervention phase of testing. Additional threats to interval validity include practice effects, often described as 'test savvy', by simply repeating the testing phase participants

may have improved without the need for the educational intervention (Sim & Wright, 2002).

Limitations

The study used a small non-randomised sample from a single university, potentially affecting the accuracy of the results. Furthermore the use of simulation and not real patient encounters limits the extent to which the result can be generalised; the study also used a non-validated questionnaire. Reactivity among participants such as the Hawthorn effect, practice and fatigue effects may have influence behaviours affecting the overall results either positively or negatively. Finally this is a recent study and the durations of its benefits are unknown.

Conclusion

The diagnostic accuracy of undergraduate paramedics assessed by clinical simulation demonstrated a marked improvement following an educational intervention 95% compared to 25.4% pre-intervention; two of the three scenarios reached statistical significance in both diagnostic synthesis and treatment interventions. Although one scenario failed to reach statistical significance in both the synthesis and intervention domains, overall diagnostic accuracy was improved and the provision of a relevant antidote increased. The post-intervention data demonstrate a noticeable shift towards deployment of toxidromes by participants. Furthermore, the study has indicated improved levels of confidence in three of the four confidence based questions; no gender differences were found in either the diagnostic synthesis or treatment intervention domain.

Author contributions

Contributors: JT and JC analysed the Data. JT wrote the text.

Conflict of interest

None declared.

Funding

None.

References

- Bowen, J. L. (2006). Educational strategies to promote clinical diagnostic reasoning. *New England Journal of Medicine*, 355, 2217–2225. doi: 10.1056/NEJMra054782.
- Bowling, A. (2009). *Research methods in health: Investigating health and health services* (3rd ed.). Maidenhead: Open University Press.
- Clarke, S. F., Dargan, P. I., & Jones, A. L. (2005). Naloxone in opioid poisoning: Walking the tightrope. *Emergency Medicine Journal*, 22, 612–616. doi: 10.1136/emj.2003.009613.
- Croskerry, P. (2002). Achieving quality in clinical decision making: Cognitive strategies and detection of bias. *Academic Emergency Medicine*, 9, 1184–1204. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1197/aemj.9.11.1184/pdf>.
- Edwards, T. (2011). Does the introduction of a targeted heart failure training intervention improve diagnostic accuracy amongst undergraduate paramedics assessed through medical simulation? *Journal of Paramedic Practice*, 3, 436–441. doi: 10.1136/emj.2010.108605.12.
- Fleming, A., Cutrer, W., Reimschisel, T., & Gigante, J. (2012). You too can teach clinical reasoning! *Pediatrics*, 130, 795–797. doi: 10.1542/peds.2012-2410.
- Frendl, D. M., Strauss, D. G., Underhill, B. K., & Goldstein, L. B. (2009). Lack of impact of paramedic training and use of the Cincinnati prehospital stroke scale on stroke patient identification and on-scene time. *Stroke*, 40, 754–756. doi: 10.1161/STROKEAHA.108.531285.
- Greene, S. L., Dargan, P. I., & Jones, A. L. (2005). Acute poisoning: Understanding 90% of cases in a nutshell. *Postgraduate Medical Journal*, 81, 204–216. doi: 10.1136/pgmj.2004.024794.
- Greenhalgh, T. (2010). *How to read a paper: The basics of evidence-based medicine* (4th ed.). Chichester: Wiley-Blackwell.
- Halter, M., & Marlow, T. (2005). *Evaluation of the emergency care practitioner scheme in London*. London: Faculty of Health and Social Care Sciences.
- Hansson, M., & Wigblad, R. (2006). Recontextualizing the Hawthorne effect. *Scandinavian Journal of Management*, 22, 120–137. doi: 10.1016/j.scaman.2005.12.003.
- Hassan, T. B., Pickett, J. A., Durham, S., & Barker, P. (1996). Diagnostic indicators in the early recognition of severe cocaine intoxication. *Journal of Accident and Emergency Medicine*, 13, 261–263. doi: 10.1136/emj.13.4.261.
- Jensen, J. L., Croskerry, P., & Travers, A. H. (2009). Paramedic clinical decision making during high acuity emergency calls: Design and methodology of a Delphi study. *BMC Emergency Medicine*, 9, 17. doi: 10.1186/1471-227X-9-17.
- Kelly, C. A., Upex, A., & Bateman, D. N. (2004). Comparison of consciousness level assessment in the poisoned patient using the alert/verbal/painful/unresponsive scale and the Glasgow Coma Scale. *Annals of Emergency Medicine*, 44, 108–113. doi: 10.1016/S0196064404003105.
- Kerns, W., 2nd. (2007). Management of beta-adrenergic blocker and calcium channel antagonist toxicity. *Emergency Medical Clinics of North America*, 25, 309–331. doi: 10.1016/j.emc.2007.02.001.
- Kerr, G. W., McGuffie, A. C., & Wilkie, S. (2001). Tricyclic antidepressant overdose: A review. *Emergency Medicine Journal*, 18, 236–241. doi: 10.1136/emj.18.4.236.
- Lockey, A. S. (2001). Teaching and learning. *Emergency Medicine Journal*, 18, 451–452. doi: 10.1136/emj.18.6.451.
- Mofenson, H. C., & Caraccio, T. R. (1985). Toxidromes. *Comprehensive Therapy*, 11, 46–52.
- Newsholme, E. A., & Leech, A. R. (2009). *Functional biochemistry in health and disease*. Hoboken, NJ: Wiley; Chichester: John Wiley.
- Parahoo, K. (2006). *Nursing research: Principles, process and issues* (2nd ed.). London: Macmillan.

- Peat, J. K. (2002). *Health science research: A handbook of quantitative methods*. London: SAGE Publications.
- Prideaux, D., & Bligh, J. (2002). Research in medical education: Asking the right questions. *Medical Education, 36*, 1114–1115. doi: 10.1046/j.1365-2923.2002.01411.x.
- Shepherd, G. (2006). Treatment of poisoning caused by beta-adrenergic and calcium-channel blockers. *American Journal of Health-System Pharmacy, 63*, 1828–1835. doi: 10.2146/ajhp060041.
- Sim, J., & Wright, C. C. (2002). *Research in health care: Concepts, designs and methods*. Cheltenham: Nelson Thornes.
- Siriwardena, A. N., Iqbal, M., Banerjee, S., Spaight, A., & Stephenson, J. (2009). An evaluation of an educational intervention to reduce inappropriate cannulation and improve cannulation technique by paramedics. *Emergency Medicine Journal, 26*, 831–836. doi: 10.1136/emj.2008.071415.
- Sterrett, C., Brownfield, J., Korn, C. S., Hollinger, M., & Henderson, S. O. (2003). Patterns of presentation in heroin overdose resulting in pulmonary edema. *American Journal of Emergency Medicine, 21*, 32–34. doi: 10.1053/ajem.2003.50006.
- Whitbread, M., Leah, V., Bell, T., & Coats, T. J. (2002). Recognition of ST elevation by paramedics. *Emergency Medicine Journal, 19*, 66–67.
- Yates, C., & Manini, A. F. (2012). Utility of the electrocardiogram in drug overdose and poisoning: Theoretical considerations and clinical implications. *Current Cardiology Reviews, 8*, 137–151. doi: 10.2174/157340312801784961.