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New Zealand paramedics are ready for an autonomous pre-hospital thrombolysis protocol

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Education

New Zealand paramedics are ready for an autonomous pre-hospital thrombolysis protocol

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Abstract

Introduction

Internationally, autonomous paramedic-delivered pre-hospital thrombolysis (PHT) administration for ST-elevation myocardial infarction patients has proven to be a highly effective strategy in facilitating expedited delivery of this treatment modality. However, current New Zealand models rely on physician authorised telemetry-based systems which have proved problematic, particularly due to technological failings. The aim of this study is to establish whether current paramedic education in New Zealand is sufficient for the introduction of an autonomous paramedic clinical decision-making model of PHT.

Methods

A one-hour workshop introduced a new PHT protocol to 81 self-selected paramedic participants – both rural and metropolitan based – from New Zealand. Paramedics were then tested in protocol application through completion of a scenario-based standardised written test. Four written scenarios constructed from actual field cases assessed 12-lead electrocardiogram interpretation, understanding of protocol inclusion/exclusion criteria, and treatment rationale. Ten multiple-choice questions further tested cardiac and pharmacology knowledge as well as protocol application.

Results

Overall clinical decision-making showed a sensitivity of 92.0% (95% CI: 84.8–96.5), and a specificity of 95.6% (95% CI: 89.1–98.8). Electrocardiogram misinterpretation was the most common error. University educated paramedics (n=44) were significantly better at clinical decision-making than in-house industry trained paramedics (n=37) (p=0.001), as were advanced life support paramedics (n=36) compared to paramedics of lesser practice levels (n=45) (p=0.006).

Conclusion

Our New Zealand paramedic sample demonstrated an overall clinical decision-making capacity sufficient to support the introduction of a new autonomous paramedic PHT protocol. Recent changes in paramedic education toward university degree programs are supported.

Keywords:

paramedic; thrombolytic therapy; myocardial infarction; electrocardiography; cardiovascular disease; myocardial reperfusion

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Introduction

Thrombolysis remains the primary treatment modality for many patients suffering ST-elevation myocardial infarction (STEMI) throughout New Zealand. This is particularly the case in regional centres where most receiving hospitals do not have the interventional cardiology facilities needed to provide the preferred and superior treatment of percutaneous coronary intervention (PCI). A crucial determinant to the success of thrombolysis is the time to treatment. Early treatment (<2 hours) confers the greatest clinical benefit: prompt restoration of coronary blood flow can preserve left ventricular function and enhance both early and long-term survival (1,2). For these reasons the delivery of thrombolysis in the pre-hospital setting by trained paramedics has been conceptualised as a means to bring this treatment to the patient and reduce total ischaemic time. Paramedics are often the first health practitioners to attend patients experiencing an acute myocardial infarction (AMI), and are therefore well positioned to expedite the process of STEMI recognition and acute treatment/management (3,4). Paramedic-delivered pre-hospital thrombolysis (PHT), both in New Zealand and elsewhere, has been shown to significantly reduce morbidity and mortality among STEMI patients compared to those who receive the treatment in-hospital after ambulance transport from the field (2,5-6).

The current approach for paramedic-delivered PHT in New Zealand (at all practice levels) utilises a physician-authorised telemetry model. Paramedics attend the patient and transmit a 12-lead electrocardiogram (ECG) from the scene to a hospital-based physician, who may (or may not) authorise the paramedic to administer thrombolysis (8). This telemetry-based approach has proved time consuming and problematic, particularly due to technological failings such as poor mobile phone coverage and subsequent transmission issues (9). This has been our experience in a pilot physician-authorised PHT program in Northland, New Zealand. Transmission delays occurred a third of the time, and although 35 patients received PHT over a 2 year period, a further seven eligible patients were denied treatment because of complete transmission failure (10).

A possible solution is to remove both physician consultation and the need for ECG transmission from the process. Paramedics assess the patient and make an independent clinical decision as to whether or not thrombolysis is indicated. Having already been trialled in several countries such as England, Wales and the Netherlands, this autonomous paramedic model is thought to be the most time efficient approach to PHT delivery (9-13).

In New Zealand, paramedics make clinical decisions and treat according to written protocols, a form of 'standing orders'. So the primary research question we asked was: Do New Zealand paramedics possess the necessary prerequisite

skills and knowledge to permit autonomous decision-making for PHT, under protocol guidance? Specifically, this includes accurate 12-lead ECG interpretation skills and an understanding of both acute cardiac pathology and principles of pharmacology. Our second research question was: Do any associations exist between our paramedic groups' clinical decision-making abilities and key demographic characteristics such as clinical education pathway, length of service, current practice level and area predominantly worked, ie. rural or metropolitan.

New Zealand paramedic education and training has evolved rapidly in recent years, coinciding with increasing complexities in patient care due to an ageing population who exhibit greater comorbidities and increased prescribed drug therapy. A transition from solely in-house industry-based training to a university-based paramedic undergraduate degree program began in 2002. Therefore, this study also enabled us to compare these two education pathways in regard to assessing paramedics' abilities to independently determine patient eligibility for PHT in simulation and under protocol guidance.

Methods

Study design

This was a quasi-experimental post-test only study.

Setting

The study was conducted within St John Ambulance Service, New Zealand's largest ambulance provider which operates over 97% of the country. Study workshops were held at ambulance stations in five different locations throughout the country: Whangarei, Auckland, Tauranga, Nelson and Christchurch, to ensure a north/south, urban/rural spread.

Participants

Eighty-one paramedics were recruited via advertisements on ambulance station notice boards. Inclusion criteria were: employed on front-line ambulances, with current Authority to Practice (ATP); educated in 12-lead ECG interpretation, by either educational pathway. That is, educated by either in-house industry-based training or by university degree programs. Participants were also required to sign a consent form as per ethical requirements.

Sample size

It was calculated that 81 participants were required for this study. This number was based on an a-priori power analysis of data from two previous similar studies that also explored paramedic clinical decision-making with regards to PHT (9,12). This was assuming a sensitivity of 70%, an accuracy measure of $\pm 10\%$, and a statistical significance level of $\alpha=0.05$, denoting a 95% confidence interval (CI). Our 81 participants make up approximately 7.1% of an actual population size of 1127 St John Ambulance personnel eligible to participate in the study.

Procedure

An inclusion/exclusion protocol for PHT by autonomous paramedics was introduced to study participants in a one hour workshop. This was followed by a summative scenario-based standardised written test, which assessed 12-lead ECG interpretation, identification of patients for whom the protocol was indicated/contraindicated, and general knowledge of protocol application.

Data collection

Subjects completed a 'Participant Demographic Questionnaire', detailing gender, age, length of service, current practice level, area predominantly worked in (urban versus rural) and educational pathway. These data were compared with national ambulance workforce data obtained from St John, New Zealand's primary ambulance service provider.

The 'Autonomous Paramedic PHT Protocol Written Test' was to be completed within 50 minutes. Four scenarios were presented, each with a 12-lead ECG plus clinical signs and symptoms. Scenarios 1, 3 and 4 all had STEMI ECGs. Participants were asked to interpret the ECG, decide if PHT was indicated or contraindicated for the patient, and explain rationale. The four scenarios were based on actual field cases; PHT was indicated for two cases and contraindicated for the other two; model answers were verified by three consultant cardiologists. The STEMI ECG criteria utilised was: ST-elevation ≥ 1 mm in two or more anatomical contiguous limb leads; and/or ST-elevation ≥ 2 mm in two or more anatomically contiguous precordial leads.

Ten multiple-choice questions followed which further probed key details of correct protocol application along with both cardiac and pharmacology knowledge relative to PHT.

Data analysis

Data was analysed using SPSS, Version 19. Demographic data was initially analysed as one dataset and given this data was categorical, frequencies were used to obtain descriptive statistics. Confidence intervals were set at 95% and an alpha level of 0.05 was considered statistically significant. Non-parametric testing was utilised, given data was dichotomous, categorical or ordinal.

The written test scenarios were categorised as either: 'fully correct' (correct 12-lead ECG interpretation, correct treatment decision, correct rationale); 'partially correct' (correct treatment decision, but based on incorrect ECG interpretation and/or only partially correct rationale); or 'misdiagnosis' (incorrect treatment decision, for whatever reason). We calculated overall sensitivity (fully correct clinical decision-making for true positive scenarios) and overall specificity (fully correct clinical decision-making for true negative scenarios). Associations

between written test scenario scores and demographic characteristics were analysed using a chi-square test for independence (with Yates Continuity Correction when cells had less than five observations).

Ethics

Ethical approval for this research was obtained from the Health and Disability Commission Multi-Region Ethics Committee (MEC/12/EXP/025), and from the Auckland University of Technology Ethics Committee (application number 12/94).

Results

Participant demographics

The participants were predominantly male (58%), with 43% having been in the service 5–10 years, and a further 27% more than 10 years. In terms of educational pathway: 31% of participants had received only in-house industry-based training, 35% had graduated from a university paramedic degree program, and the remainder were a mixture, ie. industry-based training plus some supplementary university education. Most participants worked in a metropolitan area (60%). The demographic characteristics of the participant group were similar to national workforce data (data not shown). Thus, this sample is representative of the whole.

Written test scenarios

The raw data for accuracy in clinical decision-making in the four scenarios in the written test is shown in Table 1. Participants were least fully correct in Scenario 2, but withheld treatment when it was indicated most often in Scenario 3. A positive case is one where PHT was indicated; a negative case is one where PHT was contraindicated, according to the protocol.

Table 1. Accuracy of clinical decision-making in written test scenarios (combined participant scores, n=81)

Score	Scenario			
	1 (positive case)	2 (negative case)	3 (positive case)	4 (negative case)
Fully correct	80	66	69	75
Partially correct	0	9	0	6
Misdiagnosis	1	6	12	0

Note: Positive case = pre-hospital thrombolysis treatment is indicated; Negative case = pre-hospital thrombolysis treatment is not indicated

Sensitivity in clinical decision-making was 92.0% (95% CI: 84.8–96.5) and specificity was 95.6% (95% CI: 89.1–98.8). These results were obtained through calculation of ‘fully correct’ answers only. The main reason for participants failing to be fully correct in each scenario was failure to interpret the ECG correctly. In Scenario 4, which showed a STEMI ECG, there were two contraindications present. However, six participants were ‘partially correct’ because they only recognised one of these. For the above calculations, partially correct answers were considered as incorrect. There were a total of 324 ECG interpretations in this study (81 participants x four scenarios each). ECG misinterpretation occurred 27 times – this produced an accuracy rate of 91.7%. The more common areas of misinterpretation were bundle branch blocks and left ventricular hypertrophy (LVH) with strain pattern. Electrocardiogram interpretation is summarised in Table 2.

Table 2. Accuracy of ECG interpretation

Scenario	Correct interpretation	Incorrect interpretations and number per scenario
1	Inferior STEMI	1 x LVH with strain pattern
2	RBBB	12 x LBBB 1 x inferior STEMI
3	Anterior STEMI	11 x LVH with strain pattern 1 x SR with BER
4	Inferior STEMI	1 x LBBB

Note: STEMI = ST-elevation myocardial infarction; LVH = left ventricular hypertrophy; LBBB = left bundle branch block; RBBB = right bundle branch block; SR = sinus rhythm; BER = benign early repolarisation

Multiple choice questions

Ten multiple-choice questions (MCQs) followed the written test scenarios. Seven questions were correctly answered by all participants; two questions were correctly answered by 96.2% of participants; and one question was correctly answered by only 62.9% of participants. All participants correctly answered eight or more of the 10 MCQs, with nearly three-quarters of the group (74%) answering all 10 questions correctly. The average participant score for the 10 MCQs was 9.6.

Associations between fully correct written test scenarios and demographic characteristics: There were no significant associations between the number of scenarios that were fully correct and the participants’ gender, area predominantly worked, metropolitan versus rural, length of service or age. The trend seen for age is toward younger age and number of scenarios fully correct (see Table 3).

There was a significant association between participants’ educational pathway and the number of fully correct scenarios. Participants with the greater amount of university-based education (paramedic degree graduates, and those who had completed the university requirements to qualify as an advanced life support (ALS) paramedic) (n=44) achieved fully correct scores for all four written test scenarios significantly more often when compared to participants with other educational pathways (n=37) (p=0.001). See Figure 1.

Table 3. Associations between fully correct written test scenarios and demographic characteristics

Demographic feature (n=81)	χ^2	df	p-value
Age	6.7	1	0.08
Gender	0.31	1	0.57
Area predominantly worked (rural vs. metropolitan)	0.000	1	1.00
Length of service	0.98	1	0.61
Education pathway (in-house vs. university)	14.9	1	0.001
Practice level	7.4	1	0.006

Note: χ^2 = chi-squared; df = degrees of freedom

A significant association also existed between the participants’ current practice level (as determined by ATP) and the number of fully correct scenarios. Participants currently practising at ALS level (n=36) achieved fully correct scores for all four written scenarios significantly more often than participants currently practicing as emergency medical technicians (EMTs) and intermediate life support (ILS) paramedics (n=45) (p=0.006). (Data not shown.)

Discussion

Our New Zealand paramedic sample exhibited a high standard of autonomous clinical decision-making in application of this PHT protocol in simulation – sensitivity of 92.0% (95% CI: 84.8–96.5) and specificity of 95.6% (95% CI: 89.1–98.8). Participants were able to recognise STEMI patients for whom PHT was indicated, and then apply inclusion and exclusion criteria with a high degree of accuracy. Likewise, patients who were not eligible for PHT were readily identified. Participants demonstrated sufficient cardiac and pharmacology knowledge on which to base the introduction of a new PHT guideline. These New Zealand findings are similar to standards of paramedic clinical decision-making with regards to PHT observed in England, Wales and The Netherlands (9,12,13). However, differing experimental designs make direct comparisons difficult.

Figure 1. Number of fully correct scenarios by educational pathway of participants

Note: ALS = advanced life support

The four scenarios in the written test were constructed from actual field cases carefully selected as being representative of the pre-hospital setting (16,17). 12-lead ECGs for both anterior and inferior STEMI were used because these are the two most common types of STEMIs (18). A right bundle branch block was presented: these, along with left bundle branch blocks, are a frequent STEMI mimic occurring among non-traumatic chest pain patients, particularly those with a history of ischaemic heart disease (19). Even one of the negative cases, a patient with multiple contraindications to PHT, presented with a genuine inferior STEMI. This allowed us to assess the paramedics' protocol adherence beyond a positive ECG finding.

Four scenarios was a realistic number for a 50 minute written test which also explored rationale and contained additional MCQs. Approximately 10 minutes per scenario is realistic to the working environment, where paramedics must interpret the patient's ECG and assimilate further clinical information before reaching a treatment decision. Both the number of scenarios and timeframe for each is consistent with similar studies conducted in England and Wales (9,12). However, our testing methodology enabled further insight into each participant's clinical rationale, beyond simple accuracy of ECG interpretation. By asking participants further questions to validate their treatment decision, we were able to interrogate any correct treatment decisions which were based on flawed clinical analysis and rationale.

12-lead ECG interpretation was largely accurate in the four written scenarios used, with a sensitivity and specificity comparable to international studies involving both paramedics and physicians (9,12,13,16,20). However, some areas of

common weakness were revealed. Bundle branch blocks were the arrhythmias most often misinterpreted, as was LVH with strain pattern. These have been identified as arrhythmias that often challenge frontline paramedics (15,16). Therefore, our study uncovered two clear areas of 12-lead ECG interpretation deficit. If an autonomous PHT protocol for paramedics is to be introduced, these arrhythmias should be given specific attention within the developed training package.

Paramedics in this study were able to take the new PHT protocol and apply it to the written scenarios with a high degree of accuracy in clinical decision-making. Note that in this study, paramedics were not required to memorise the new PHT protocol, the protocol was available for review during testing. This is realistic to the environment in which they work: in New Zealand paramedics are required to carry a copy of the ambulance 'Clinical Procedures and Guidelines' on their person, and are expected to consult them as necessary. Therefore it was not surprising that participants answered the study MCQs on protocol application so well, with 100% success for many questions. However, the questions which were answered less well were revealing. Twenty-one percent of the participants erroneously believed that AMI was the most common cause of ST-elevation on 12-lead ECG (Question 7). This was the same question that uncovered the paucity of understanding of strain pattern associated with LVH. These knowledge deficits are best addressed by education. Ambulance education has been in transition in New Zealand since 2002, the year that university-based degree programs were first offered. This study provides a unique snapshot of this transition period given our participants came from both older and newer educational pathways, enabling a comparison to be made.

Those paramedics that had completed a Bachelor of Health Science Paramedic degree scored significantly higher than those whose education was solely in-house industry-based. Those whose education was a mixture of both pathways scored in between these two groupings. These results do not denigrate in-house industry-based education, but are a validation of the standard of the newer university-based education. It is now a requirement of New Zealand's two ambulance services that those officers wanting to practice at either ILS or ALS paramedic level need to complete a university undergraduate paramedic degree or higher.

Unsurprisingly, those participants currently practising at ALS level showed significantly better clinical decision-making than those practising at ILS or EMT levels ($p=0.006$). Of more interest, degree qualified participants achieved higher scores in clinical decision-making even though not all were practising as ALS paramedics ($p=0.001$). In fact the degree qualified participants were at all levels of current practicing qualification – EMT, ILS and ALS. This is because ATP is granted by the ambulance industry, and university graduates begin their employment as EMTs and then progress to ILS and potentially to ALS. This finding suggests that the higher standard in clinical decision-making shown by university educated paramedics may be due not so much to their current practice level or associated on-road experience but more to the greater depth and duration of their education.

Determining patient eligibility for primary PCI is very similar to that of PHT but with far fewer contraindications. Therefore, within New Zealand's main metropolitan centres our results provide support for a model of autonomous paramedic referral and direct transfer of STEMI patients from the field to the cardiac catheterisation lab where PCI is performed. This approach, which bypasses the hospital emergency department, has been shown to significantly reduce PCI delivery times more so than telemetry-based models and in-hospital strategies, with positive effects on patient mortality (21-24).

Limitations

The 81 paramedics were self-selected and therefore presumably a more proactive group. This limits the generalisability of our results to the greater New Zealand St John Ambulance paramedic workforce, consisting of 1127 paid full-time officers who may be eligible to administer PHT. Protocol application was tested in simulation. Therefore, paramedics were not exposed to real-life factors, such as fatigue associated with circadian low points, which may potentially impact on their clinical decision-making. However, field testing of our protocol was deemed unethical at such an early juncture without first investigating our paramedics' capabilities in simulation.

Conclusion

This study provides evidence of the abilities of a self-selected New Zealand paramedic sample in 12-lead ECG interpretation and in clinical decision-making with regards to PHT, and supports recent changes in education within the profession. It adds weight to the argument that autonomous paramedic administration of PHT is an effective way to provide this life-saving treatment to STEMI patients. We believe that this study would serve as a useful tool to support and inform a pilot program of autonomous paramedic PHT in the New Zealand ambulance services, in terms of staff-training and introductory requirements.

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Conflict of interest

The authors declare they have no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

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