Short communication

Resuscitation quality assurance for out-of-hospital cardiac arrest – Setting-up an ambulance defibrillator telemetry network

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\textbf{A B S T R A C T}

\textbf{Background:} Out-of-hospital cardiac arrest (OHCA) is a leading cause of pre-hospital mortality. Chest compressions performed during cardiopulmonary resuscitation aim to provide adequate perfusion to the vital organs during cardiac arrest. Poor resuscitation technique and the quality of pre-hospital CPR influences outcome from OHCA. Transthoracic impedance (TTI) measurement is a useful tool in the assessment of the quality of pre-hospital resuscitation by ambulance crews but TTI telemetry has not yet been performed in the United Kingdom. We describe a pilot study to implement a data network to collect defibrillator TTI data via telemetry from ambulances.

\textbf{Methods:} Prospective, observational pilot study over a 5-month period. Modems were fitted to 40 defibrillators on ambulances based in Edinburgh. TTI data was sent to a receiving computer after resuscitation attempts for OHCA.

\textbf{Results:} 58 TTI traces were transmitted during the pilot period. Compliance with the telemetry system was high. The mean ratio of chest compressions was 73\% (95\% CI 69–77\%), the mean chest compression rate was 128 (95\% CI 122–134). The mean time interval from chest compression interruption to shock delivery was 27 s (95\% CI 22–32 s).

\textbf{Conclusion:} Transthoracic impedance analysis is an effective means of recording important measures of resuscitation quality including the hands-on-the-chest time, compression rate and defibrillation interval time. TTI data transmission via telemetry is straightforward, efficient and allows resuscitation data to be captured and analysed from a large geographical area. Further research is warranted on the impact of post-resuscitation reporting on the quality of resuscitation delivered by ambulance crews.

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few OHCA and skill retention can be problematic. There is a need to monitor compliance of CPR performed by ambulance crews in accordance with current international resuscitation guidelines, as previous investigation of pre hospital practice has demonstrated poor compliance with recommended chest compression depth and rate, compounded by pauses in delivery of chest compressions.

Determining the quality of pre-hospital resuscitation performed by ambulance crews in the field is technically difficult, but crucial if pre-hospital care of OHCA patients is to improve.

Transthoracic impedance (TTI) measurement is a useful tool in the assessment of the quality of pre-hospital resuscitation by ambulance crews. The TTI signal is already recorded through the pads of many models of external defibrillator without the need for any further equipment to be placed on the patient. Both chest compressions and ventilations result in identifiable changes in the TTI trace. Analysing the trace allows a variety of resuscitation metrics including the hands-on-the chest time, compression rate and time-to-shock intervals to be accurately measured.

Analysing the TTI trace from individual defibrillators following a resuscitation attempt requires the data to be downloaded to a computer before analysis with software can occur. Data can be downloaded from the defibrillator using a direct cable connection or transmitted wirelessly via telemetry. The former requires the defibrillator to be taken to a download station post-resuscitation, is labour intensive, may delay ambulance crews returning to clinical duties and may result in a poor data capture rate. Sending the TTI data via telemetry allows more convenient data transmission post-resuscitation, which can be achieved directly from the ambulance and allows remote data access.

Logging and analysis of TTI data from ambulance defibrillators after OHCA does not yet occur routinely in the United Kingdom. We describe a pilot study to implement a data network to collect defibrillator TTI data via telemetry from ambulances in the City of Edinburgh, Scotland.

2. Methods

Ambulance crews in Scotland currently use the LIFEPAK 12 (Physio Control) defibrillator and transmit 12-lead electrocardiograph (ECG) data to Cardiology units using a low bandwidth telemetry system. The data file containing the TTI trace for each OHCA event was found to be significantly larger (500 kb – 3.5 MB) than a 12-lead ECG and transmitting such a large data file via telemetry was initially found to be problematic. Attempting to connect the defibrillator to a mobile telephone for data transmission resulted in frequent signal fallout and unacceptably long (>20 min) data transmission times.

In our pilot project general packet radio service (GPRS) modems were fitted to 40 defibrillators on ambulances based at Edinburgh City Ambulance Station. This enabled faster, reliable data transmission. The modems were housed in a sealed case attached to the rear of the defibrillator and connected via serial cable. Operation of the modem was automatic and did not require any intervention by the ambulance crews.

Ambulance crews were informed via email and posters of the need to transmit the TTI trace following a resuscitation attempt and a sticker with detailed instructions was placed on each defibrillator as a reminder.

Following each resuscitation attempt, the attending ambulance crew selected the respective case and instructed the defibrillator to transmit the data. The TTI trace was typically transmitted in under 2 min using this technology. A choice of two different receiving targets was pre-configured on the defibrillator menu allowing transmission of a resuscitation attempt after OHCA or a 12-lead ECG in patients with suspected myocardial infarction as per the existing local protocol.

The TTI data packets are sent via GPRS and worldwide web to a LIFENET Server (Physio-Control). The LIFENET server then directs the data packet securely onwards to a receiving computer or multiple receiving destinations. No patient data is held on the server. To receive the TTI data, a computer with a permanent broadband internet connection is required. The data packet is stored and analysed using proprietary software (CODESTAT, Physio Control). The system can be configured to send an email notification to the study team on receipt of a TTI trace. The LIFENET system is a subscription service. The cost will vary depending on local mobile telephone operators but the approximate monthly cost is £30 per ambulance and £375 per hospital.

Importantly, we chose not to include patient-identifiable data in the transmission. Clinical data were matched probabilistically to the date and time of transmission and the individual defibrillator.

After receipt of the TTI trace, CODESTAT software was used to calculate the no-flow ratio, compression rate and time interval to administer defibrillatory shocks. A resuscitation report was generated that was printed and sent as part of feedback and training to the attending ambulance crew.

3. Results

During the initial pilot study period (1/11/2009 to 1/4/2010) 58 TTI traces were transmitted following OHCA. We found compliance with the system amongst ambulance crews to be high with many positive comments received on the usefulness of receiving post-resuscitation reports.

In two cases (3%), ambulance crews reported being initially unable to send the TTI data packet but when the ambulance moved location the data was sent successfully, indicating a region with poor GPRS signal as the likely cause of the failure.

All TTI traces were received and analysed on a single computer. During the study period, a hard drive error on the receiving computer resulted in permanent loss of data for 18 traces. Subsequently, a data back-up system was installed to protect against hardware failure.

From the initial 58 TTI traces received, the mean ratio of chest compressions was 73% (95% CI 69–77%), the mean chest compression rate was 128 (95% CI 122–134). There were 19 resuscitation attempts where at least once shock was administered from the defibrillator. The mean time interval from chest compression interruption to shock delivery was 27 s (95% CI 22–32 s)

4. Discussion

This is the first study to describe TTI telemetry in the United Kingdom. We found establishing a telemetry network to be an effective, time-efficient means of pre-hospital resuscitation data collection. Using GPRS technology to transmit TTI traces proved to be a reliable, rapid means of transmitting data to a remote computer for analysis. Data security and back-up is important to prevent loss of data in the event of a hardware failure.

Previous studies have highlighted the need to collect data on and monitor the quality of CPR performed by ambulance crews but few studies have described the methodology for collecting such data. Initial TTI data collected in our region has demonstrated the need to improve pre-hospital resuscitation practice.

A limitation of this pilot study was that we did not identify all OHCA cases attended by the modem-equipped ambulances during the study period to measure overall ambulance crew compliance with transmitting the traces.

5. Conclusion

Evaluating quality of pre-hospital resuscitation practice is important to assure quality and to improve outcomes from OHCA. TTI analysis is an effective means of recording important measures of resuscitation quality including the hands-on-the-chest time, compression rate and defibrillation interval time. TTI data transmission via telemetry is straightforward, efficient and allows resuscitation data to be captured and analysed from a large geographical area. Further research is warranted on the impact of post-resuscitation reporting on the quality of resuscitation delivered by ambulance crews.

Conflict of interest statement

Dr. Lyon is supported by a Clinical Research Fellowship from Chest, Heart and Stroke Scotland. The modems and computer software used in this pilot study were supplied by Physio-Control. No funding was received for this study.

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