

Paper

Faxing ECGs from peripheral hospitals to Tertiary Paediatric Cardiology Units- Is it Safe and Sustainable?

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Accepted 21 November 2013

ABSTRACT.

Introduction. Recent local involvement with the United Kingdom “Safe and Sustainable review of paediatric cardiology services” has highlighted the need for development of clinical networks and improvement of the communication infrastructure within and between teams.

One common communication between peripheral and tertiary hospitals is facsimile transfer of electrocardiograms. The quality of fax transmission can be variable, raising concerns regarding the quality of the received image, accuracy of the diagnosis and appropriateness of the resultant advice.

Methods. We performed a systematic quality evaluation of faxed ECGs to determine whether they should be replaced on the basis of patient safety and information governance.

A sample of 50 ECGs was selected from over 300 which had been faxed to our tertiary department. These were scored according to a structured system leading to a 10 point Likert scale, assessing technical quality and the ability to make a clinically relevant assessment of the information.

Results. Only 1 from 50 faxed ECGs fulfilled all 9 objective criteria set. Heart rate and quadrant of the QRS axis were only identifiable in 10%. Comparing the faxed ECGs with the rating given to an original ECG confirmed a significant difference in the interpretability of faxed and original ECGs ($p < 0.05$).

Conclusion. Our study suggests that faxed ECGs do not provide consistent, accurate diagnostic information. It suggests that this currently widespread practice should be considered as a potential patient safety issue within developing paediatric cardiology networks. We would recommend that faxing of ECGs be replaced with scanning of ECGs, transmitted via secure email.

INTRODUCTION

In 2008, Safe and Sustainable was set up to review the provision of children’s congenital cardiac services with an aim to concentrate surgical and interventional cardiology activity in fewer centres¹. This change requires improved communication infrastructure between the networked hospitals. Although initially restricted to hospitals in Great Britain; the principles of the review have recently been applied to the paediatric cardiology service in Northern Ireland.

One common communication between peripheral and tertiary hospitals is facsimile (fax) transfer of electrocardiograms (ECGs), performed in peripheral hospitals. ECGs are a vital diagnostic tool for evaluating heart disease in children^{2,3}. The main method of transmitting ECGs is via fax machine. We confirmed by telephone survey that only one of the eleven current UK specialist surgical centres didn’t accept faxed ECGs. The quality of fax transmission can be variable raising concerns regarding the quality of the received image, and therefore the accuracy of the diagnosis, and appropriateness

of the resultant advice. Ideally the quality of an ECG should be the same irrespective of what medium it is displayed on⁴.

We evaluated the readability of faxed ECGs to the paediatric cardiology ward of Bristol Children’s Hospital, to determine whether this system should be replaced on the basis patient safety and information governance. We also report preliminary evaluation of scanning and emailing ECGs as an alternative to facsimile transmission.

METHODS

A sample of 50 ECGs were selected using a random number generator from over 300 that had been faxed to the department from more than 20 secondary care referral centres between

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TABLE 1.

Criteria guide given to clinicians for assessment of the faxed ECG's. These assessment criteria were used to guide the Likert scoring of overall interpretability.

Category	Assessment	Notes
Assessment of background ECG paper features	Can the small (1mm) boxes be determined throughout the ECG page?	Are these clear enough to perform calculation of cardiac cycle time intervals?
	Can the large (10mm) boxes be determined throughout the ECG page?	
Assessment of the major ECG complexes	Can you adequately assess the presence and morphology of "p" waves throughout the ECG page?	
	Can you adequately assess the presence and morphology of QRS complexes throughout the ECG page?	
	Can you adequately assess the presence and morphology of "t" waves throughout the ECG page?	
Assessment of rate and rhythm	Can you confidently estimate the heart rate from the ECG trace?	Accurate enough to determine (bpm): <50; 50-75; 75-100; 100-125; 125-150; 150-175; 175-200; >200
	Can you confidently assess the basic underlying rhythm from the ECG trace?	ie: Sinus rhythm; narrow complex tachycardia broad complex tachycardia; bradycardia.
Axis	Can you confidently assess the QRS axis from the ECG trace?	Accurately enough to assign a quadrant to the axis.
Key intervals	Can you confidently assess the PR and QT intervals from the ECG trace?	This does not need to be in all leads.

January 2011 and September 2012. The fax machine used to receive all the ECGs was the same (Panasonic UF-4500 plain paper Laser facsimile).

Using the criteria outlined in table 1, the faxed ECGs were categorised according to predetermined criteria and given a semi-quantitative Likert quality score of 1-10 (1= Completely uninterpretable; 10= Interpretable and equivalent to an original ECG) by the study team (2 cardiology consultants & 3 registrars). Median Likert scores were then calculate for each ECG analysed.

RESULTS

The quoted specific quality targets were (table1):

1. Clear delineation of the 1mm and 10mm background squares.
2. Adequate delineation of all complexes on the ECG paper.
3. Ability to calculate heart rate, QRS axis, QT and PR intervals and determine rhythm.

Only 1 ECG out of the 50 fulfilled all of these criteria for >50% of the reviewers. In 72% of ECGs the 1mm squares were not discernable. 42% of the ECGs had indiscernible 10mm squares. A lack of background ECG squares meant that the rate and the axis could not be accurately calculated.

The rate, rhythm and axis were only calculable in 10% of the ECGs reviewed. The basic rhythm was identifiable in 84%, however this was limited to recognition of sinus rhythm or a narrow or broad complex tachycardia or bradycardia. Specific electrophysiological diagnoses were not sought.

Likert scoring.

The median Likert scoring summary is shown below. The majority of ECGs scored a median of either 4 or 5 out of 10 (n=26), meaning they were either very difficult or difficult to interpret. No faxed ECG scored the rating 10/10 for any reviewer.

- 2 ECGs were completely uninterpretable (Likert 1&2)
- 18 ECGs were very difficult to interpret (Likert 3&4)
- 24 ECGs were difficult to interpret (Likert 5&6)
- 5 ECGs were interpretable without difficulty (Likert 7&8)
- 1 ECG was classed as being easy to interpret as an original ECG print (Likert 9&10)

Hence, only 12% of the ECGs were interpretable without any difficulty. Furthermore, the mean average rating calculated from the data was 4.92 out of 10.

To ensure quality, the technical interpretation of a faxed ECG should be the same as an original ECG printout. All original ECGs were positively screened at the time of referral to ensure that they were technically interpretable before faxing and would therefore achieve a score of 10 on our rating scale, thus we were able to carry out a 2 tail, equal variance t-test comparing a sample of original ECGs with the scores apportioned by the reviewing cardiology consultants and registrars to our faxed ECGs. The mean difference in scores was significant at 4.7 ($p < 0.05$.)

DISCUSSION

Assessment of ECG data particularly in congenital heart disease should always be performed as part of a complete clinical assessment. Our data suggests that objective assessment of faxed ECGs does not reliably provide contributory diagnostic information. Statistically, the faxed ECGs are less technically interpretable than original printed ECGs. This should lead us to change our practice and use a different system to review ECGs faxed from units within our networks.

Scan and Email rather than Facsimile.

We propose that e-mailing a scanned ECG rather than faxing is a viable way to improve standards. We scanned several test ECGs to determine the best compromise between image quality and file size. We noted an acceptable level was achieved when selecting a JPEG image with 150 dots per inch (DPI) and an 8 bit colour depth. This allowed the file size to be less than 1.2 megabytes (Mb). The tests were conducted using a Hewlett Packard Scanjet G4010.

Scanning the ECG also allows the sender to assess the quality of the image before it is sent, which is not usually possible when faxing. E-mail transmission methods would need to comply with NHS and local information governance guidelines to ensure confidentiality⁵. This could be achieved via a dedicated group NHSnet email account dedicated to receiving these ECGs. As the file sizes are low (<1.2Mb) there should not be an issue in terms of server storage space. Long-term archiving and retrieval of the electronic files would be easier without concerns regarding degradation of printed image quality.

The sample size of this study is small and although only one fax machine was used to receive the images, we are assuming

similar quality from other fax machines in other departments in extrapolating our findings. We did not collect any data on missed diagnoses; inappropriate transfer of patients; delay in therapy or inappropriate therapy which may all add significant weight to this study.

CONCLUSION

Interpretation of faxed ECGs has become part of the day-to-day communication between tertiary centres and the hospitals in their networks. Secondary centres with experience of developing telemedicine networks in paediatric cardiology would find incorporation of an electronic ECG transmission system quite simple⁶. Our study confirms that fax transmission does not deliver data of comparable quality to an original ECG. We propose that networks change to transmission of ECGs via scanning and emailing them as small files. This should improve the quality and reliability of diagnoses communicated between tertiary hospitals and their networked units.

The authors have no conflict of interest

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