Original Article

Prospective National Audit of Major Gastrointestinal Complications of Transesophageal Echocardiography Studies in Children

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ABSTRACT

Background: Perioperative trans-esophageal echocardiography ('TEE') is widely used for the assessment of anatomy/repair of congenital cardiac defects. It is recognised that there are risks associated with its use.

Aims: We wished, by means of a contemporaneous prospective national audit over a six-month period, to establish what proportion of TEE studies in children are complicated by major upper gastrointestinal or upper aerodigestive tract trauma.

Methods: After obtaining appropriate local institutional ethics committee approval, a national prospective audit of the rate and severity of gastrointestinal complications of trans-esophageal echocardiography studies in anaesthetised adult cardiology and cardiac surgical patients was conducted by the Association of Cardiothoracic Anaesthesia and Critical Care in the United Kingdom and Ireland during the twelve months of 2017. During the second six months of the audit, the Congenital Cardiac Anaesthesia Network (an organisation including anaesthetists with a paediatric cardiac anaesthetic practice in all the United Kingdom cardiac surgical centres) prospectively audited the incidence of such complications of TEE studies in children.

Results: A total of 1,059 studies were included in this six-month paediatric audit. There were no reports of the specified major complication.

Statistical Analysis: The zero incidence of the major complication is consistent with a worst possible incidence of five per thousand TEE examinations.

Conclusions: Such potentially reassuring information could be included in discussions with patients or families about the risk of trans-esophageal studies in children.

Keywords: Audit, complications, paediatric, trans-esophageal echocardiography

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INTRODUCTION

Echocardiography is one of the fundamental imaging modes in the diagnosis and management of structural congenital heart disease.[1] Its use in the perioperative period is widespread and may be performed either by the epicardial or the trans-esophageal route. Each mode has its own particular strengths and weaknesses and there may be institutional preference for one form of imaging over another. Nevertheless, the use of TEE in paediatric patients is now common particularly since the development

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of miniaturised probes capable of being safely passed in patients down to as small as 2.4 kg,[2] although there are reports of its use in patients below this weight. In contrast to epicardial echocardiography, a TEE probe may be left in the patient for a relatively longer period of time and allow continuous evaluation of parameters such as contractility, cardiac output, valve function and so on.

There are a number of potentially significant complications relating to the placement of a probe in an anaesthetised child. For example, there are certain lesions, such as total anomalous pulmonary venous drainage, in which the placement of a probe may be initially avoided (i.e., until after the repair has been completed) as it may compress cardiac structures from behind and cause major changes in haemodynamic status.[2] Other complications include endotracheal tube displacement, airway/ventilation or haemodynamic compromise and trauma to the mouth, upper airway and gastrointestinal tract. Among such complications, significant trauma to the gastrointestinal tract or upper aerodigestive tract has the potential to cause additional morbidity or mortality. In addition, a history of previous esophageal surgery or significant current esophageal pathology (such as esophageal atresia) represents a relatively strong or absolute contraindication to the insertion of a probe or may be associated with an increased risk of complications from a TEE study.

MATERIALS AND METHODS

In each of the eleven UK congenital cardiac surgical centre an anaesthetist (or, in one case, a cardiologist) submitted data, at the end of each month, on the number of TEE studies (and, if applicable, the predefined major complication) conducted in their institution to one of the authors (TM) for collection and analysis. There were a variety of methods to count the number of studies completed, including:

1. Records of probe use obtained from sterilising machines and sterile hanging cupboards for probes.
2. Written records from operating room logbooks of probe use – for example those associated with the cleaning systems such as the 'Tristel Trio' system (Tristel Solutions Limited, Cambridgeshire, UK).
3. Other records of probe use from patient notes, operative logs or discussion with clinicians.

Probes were placed in anaesthetised children by a member of the anaesthetic team. Probes were withdrawn from the patient after separation from cardiopulmonary bypass, when imaging had been completed. Upon withdrawal, the probe was carefully examined for any evidence of significant blood contamination consistent with bleeding from the gastrointestinal or upper aerodigestive tract. Should there have been any suspicion of such bleeding, this would be included in the handover to the intensive care team to ensure it was appropriately monitored and/or followed up, and an audit proforma would have been completed. This form would have included the age, gender and weight of the patient, the type of surgery, the size of the probe used, the method and duration of insertion, the characteristics of the injury, predisposing factors (for example, previous esophageal surgery) and details of further investigation and management.

Major upper gastrointestinal or aerodigestive tract trauma was defined as that in which symptoms or signs were identified and which necessitated further investigation either immediately in the operating room or while the patient was on the Intensive Care Unit (for example by endoscopic evaluation or cross-sectional imaging), or relevant bleeding which was associated with a drop in haemoglobin potentially necessitating the use of transfusion of blood or blood products.

RESULTS

A total of 1,059 studies were included in the six-month audit. One additional institution reported approximately ten TEE studies at the end of six-month audit period and a decision was made to exclude this small number of studies from the dataset given the uncertainty as to whether this was an accurate measure of all probe insertions over the six-month audit period.

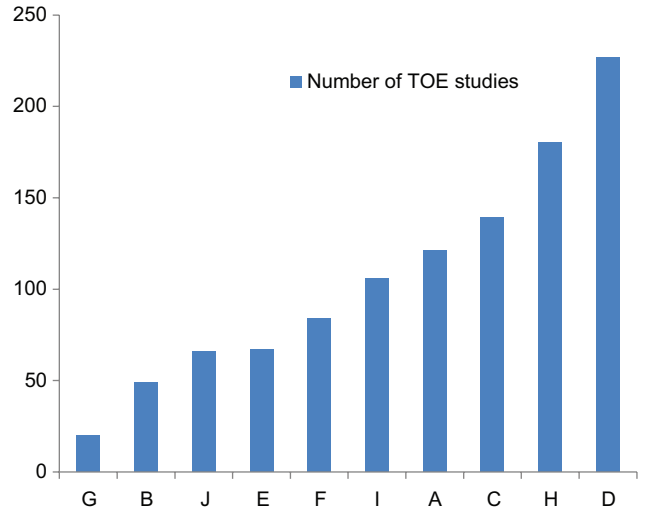
There were no reports of the predefined major complication.

Incidentally, we observed widespread variation in the use of trans-esophageal echocardiography among the institutions included in the audit, with some institutions using it relatively infrequently (for example, because of a preference for epicardial imaging); see Table 1. By way of illustration, during the audit period the institutions providing data typically undertook between over 100 to over 300 cardiac surgical procedures, in all age groups.[3]

DISCUSSION

It is possible to provide statistical analysis in binomial observational studies in which the numerator is zero.[4] 99% confidence intervals can be obtained, the lower of which is zero (as observed) with the upper confidence interval being approximately 0.0049. This would suggest that, based on this observational audit, we can be 99% confident that the 'worst possible' complication rate is approximately 5

Table 1: Breakdown of total number of probe uses among the participating institutions for the second six months of 2017 during the audit



Note that the data for institution G covers five, not six, months

per 1,000 TEE studies. By way of verification, the 'rule of three'[5] states that if there are zero events in 1,059 observations, we can be 95% confident that the chance of the event is at most 3/1059 (equivalent 95% upper confidence interval of 0.0028), i.e., a relatively lower estimate. These correspond with the limited number of previously published studies. A larger multinational audit and/or a longer duration of audit would be expected to provide greater statistical certainty as to the true incidence of this major complication.

The evidence base for the incidence of complications of TEE studies in children is limited. In 1999 Stevenson reported a series of 1650 paediatric studies.[6] The average age of the patients was 3.6 years (range 1 day to 21 years) with an average weight of 17.2 kg (range 1.6-118 kg). There were 52 complications of which 13 were failure to insert a probe. Excluding these, there were 39 complications although there were no significant bleeding episodes, esophageal injuries or deaths. A smaller study looking at the Philips s83t microTEE probe in 33 neonates and young infants (minimum weight 2.5 kg) also reported no major complications.[7] Muhuideen-Russell *et al.*,[8] reported a single case of unrecognised esophageal perforation in a neonate during a study. Randolph *et al.*,[9] assessed the impact of a series of 1002 paediatric studies; they coincidentally reported no major complications (defined as death, esophageal perforation, accidental extubation, upper gastrointestinal bleeding or endocarditis). These studies invariably report single-centre experience rather than that gathered from a larger scale study such as a national audit programme.

The results of the prospective national adult audit were reported in 2019[1]; of the 22,314 studies included in the audit there were 17 reports of major complications including upper gastroesophageal perforation or bleed. This corresponded to an incidence of 0.08% (95% CI 0.05– 0.13%) or approximately 1:1,300 examinations. Seven of these seventeen patients died as a consequence of such injury, suggesting that the development of a significant complication from trans-esophageal echocardiography probe use in adults is associated with a relatively high risk of death (41%).

There are several limitations to this study. Firstly, we found that different institutions had different systems for recording the use of a probe and it may be that some probe uses were not included in the audit. Conversely, it may be the case that some probes were recorded as being used when they weren't actually inserted into the patient for a study after being electronically recorded as having been taken from a storage cabinet or otherwise recorded as having been used. Secondly, the majority of follow-up for this audit took place immediately in the operating room or in the ICU: it is possible that some patient complications were missed out – for example a late gastrointestinal tract bleed due to gastric or esophageal mucosal damage that was not immediately apparent and/or was not subsequently reported to the patient's cardiology team or the audit team. Thirdly, there may have been cases of damage to the upper airway which manifested as respiratory symptoms post-extubation, which may have been incorrectly identified as a complication of TEE probe insertion. Finally, the audit focused on gastrointestinal or aerodigestive tract complications (to match the adult audit) and did not include other complications such as airway compromise or endotracheal tube displacement that might be particularly significant for paediatric patients with cyanotic lesions, difficult airways or significant pulmonary disease.

The pathophysiology of probe-related damage in older adult patients is likely to be different to that in children. Therefore, it is difficult to know if the incidence of major complications in the adult audit (approximately 1 in 1300) might be similar to the rate in children. Given the significant range of ages/weights of paediatric cardiac surgical patients and the choice of three probe sizes (micro, paediatric and adult sized probes) there is the potential for patient/probe size mismatch which might increase the risk of traumatic damage if an over-sized probe is used for a study.

In conclusion, this national prospective audit of trans-esophageal echocardiography studies in children suggests that the incidence of major trauma to the upper

aerodigestive tract and significant bleeding, is likely to be at worst 5 per thousand studies and may be lower than this. This information might be useful during conversations about consent for such studies and the risks associated with them.

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Conflicts of interest

There are no conflicts of interest.

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