Body temperature changes in children undergoing magnetic resonance imaging under general anaesthesia

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ABSTRACT

Introduction: Children undergoing Magnetic Resonance Imaging (MRI) under general anaesthesia are at risk of developing hypothermia since warming equipment cannot be used due to the strong magnetic field generated by the scanner. This study was carried out to investigate the range of temperature changes occurring in children undergoing MRI under general anaesthesia. **Material and methods:** From March 2013 to November 2014, 43 children aged between one and eight years old undergoing MRI Scan under general anaesthesia were recruited to the study. Axillary temperature was recorded at induction of anaesthesia and at the end of the Scan in induction area using electronic thermometer. Paired student t test was used to analyse the temperature changes. **Results:** The mean temperature change was -0.53^{0}C (SD 0.7), which was statistically significant (p<0.001), with highest temperature loss of 1.6^{0}C and highest temperature gain of 1.6^{0}C. Of the 43 children, 36 (83.7%) had temperature below 36^{0}C at recovery. Thirteen (30%) patients were hypothermic (<35^{0}C) in recovery room and none had hyperthermia (>38^{0}C). Majority of the children (n=34, 79%) had body temperature lost during MRI with mean loss of -0.79 ^{0}C (SD 0.46) and seven (16%) gained body temperature with a mean gain of 0.57 ^{0}C (SD 0.61). Two (5%) gained >1^{0}C and two (5%) maintained their initial temperature. There was no complications observed in any of the children related to temperature changes. **Conclusion:** Body temperature balance is very unpredictable in children during MRI Scan under general anaesthesia, with the majority losing body heat while few gained. It is necessary to take maximum precaution to prevent heat loss and monitor body temperature during MRI scan in children under general anaesthesia.

Key words: Resonance Imaging, body temperature, paediatric patients, general anaesthesia

INTRODUCTION

Magnetic Resonance Imaging (MRI) requires patients to stay still for long period of time in a noisy, cold and claustrophobic environment. [1] Children may require anaesthesia or sedation to complete the scan. It is well known that under anaesthesia, patients tend to lose body heat due loss of intrinsic thermoregulatory responses, redistribution of blood and cold environment. Paediatric patients, due to large surface area to body weight ratio, are more prone to develop hypothermia during anaesthesia without adequate precautions to prevent heat loss. [2, 3] The ambient temperature in MRI suite is generally kept low for the proper function of the magnetic coil. Furthermore it is difficult to use heating devices in-

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cluding fluid warmers and bear huggers, commonly used in the operating rooms as they are incompatible with MRI. However MRI produces radiofrequency radiation (RFR) that transforms into heat within the patient's tissues which may partially offset the heat loss experienced by most patients. [4, 5]

There are studies on body temperature changes during MRI scan under general anaesthesia or sedation in children, but results are conflicting. Some studies have shown rise in core body temperature during MRI scan under sedation, [6, 7] while another study reported that clinically significant core body temperature change is uncommon in children when anaesthetised with propofol. [8] Other studies have shown temperature loss during general anaesthesia for MRI scan in children. [9-11]

This study was conducted to investigate the temperature changes in children undergoing MRI scan under general anaesthesia in a tertiary referral hospital in Brunei Darussalam.

MATERIALS AND METHODS

Study Design and Study Population: This is a prospective study conducted by the anaesthetic department as part of our annual departmental audit for service improvements. Paediatric patients with ASA grade 1 & 2, aged between one and eight years old undergoing MRI studies under general anaesthesia from March 2013 to November 2014 were included in the study. All paediatric patients with baseline temperature above 38^0C or below 35^0C and ASA 3 and with ASA grade above 3 were excluded. Consent was taken from the patient's parents for the MRI scan as part of their clinical management decision.

Demographic data such as age, gender and weight were collected from the patients' electronic records kept in our hospital Bru-HIMs system. All patients received standard anaesthesia care which included the presence of at least one anaesthetist on site, standard monitoring such as saturation, electrocardiography, blood pressure, pulse rate, respiratory rate and end-tidal carbon dioxide ($ETCO_2$) monitoring. As a standard practice to conserve heat, circle absorber was used and all patients were adequately covered with blankets as much as possible during MRI studies. Axillary temperature readings measured using electronic thermometer at the time of induction of general anaesthesia and at the end of the MRI study were also collected.

The MRI scanner used was the Siemens Verio 3 Tesla MRI system located at the MRI suite at the basement of the Department of Radiology. The time of start of MRI study and the time of completion for each patient were collected and used to calculate the duration of the MRI study. Anaesthetic agents used for induction and maintenance of anaesthesia as well as airway management was carried out at the discretion of the attending anaesthetists.

Statistical Analysis: The data were entered in Microsoft Excel spreadsheet. Descriptive statistical analysis were carried out on the data using Microsoft Excel Statistical functions and results were presented as mean (SD). Children with axillary temperature below 35^0C measured at the end of the MRI study in the recovery room were considered as hypothermic and clinically management as appropriately. Temperature changes during the procedure were analysed for statistical significance using paired student t-test and a *p* value of less than 0.05 were accepted as statistical significant change. Regression analysis was carried out to assess the effect of age, weight and duration of MRI on temperature changes.

RESULTS

There was a total of 43 children undergoing MRI scanning under general anaesthesia satisfied our study inclusion and exclusion crite-

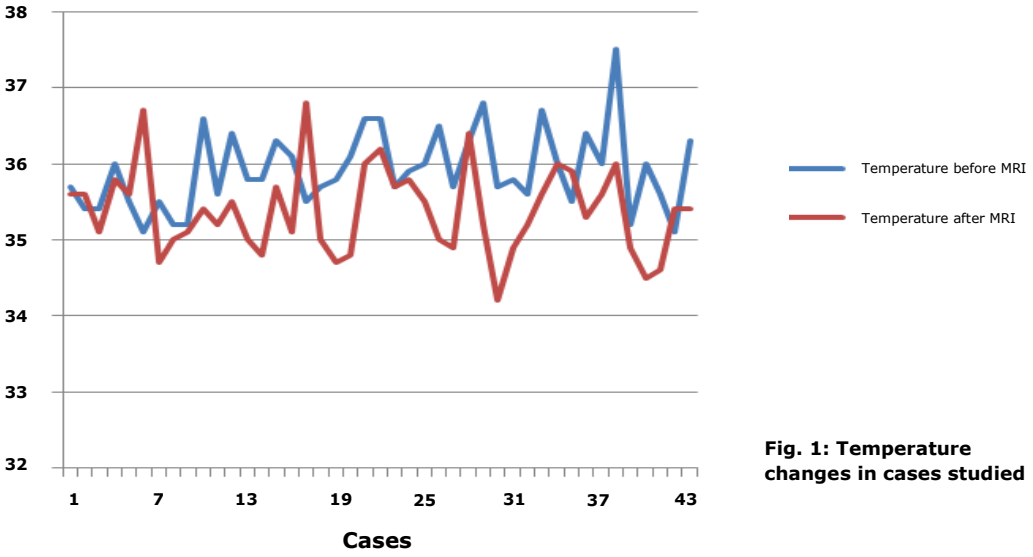

Fig. 1: Temperature changes in cases studied

ria and were included in our study. The mean age of the group was 46.76 months (SD 21.13; range 12-90 months). Twenty-five (58%) were male and 18 (42%) were female. Mean body weight was 14.47 kgs (SD 5.64; range 7.85-31.6 kg).

Intravenous induction with Propofol was used in 31 (72%) patients followed by Inhalation induction with Sevoflurane in 12 (28%) patients. Sevoflurane was the sole maintenance agent for all patients. Airway was maintained with laryngeal mask airway (LMA) in 39 (90.7%) and endotracheal tube (ETT) in four (9.3%) patients.

Total duration of MRI scan was recorded in only 23 out of 43 patients. Mean duration of procedure was 42 minutes (range 20 -90 minutes).

Generally, most patients experienced temperature loss during the imaging. Figure 1 represent the body temperature of all the patients before and after MRI. Initial body temperature at induction in 23 (53%) patients was below 36^0C. At the end of the scan 36 (83.7%) patients had temperature below 36^0C in the recovery room. Thirteen (30%) patients were clinically hypothermic with axillary temperature below 35^0C in the recovery room. No patient developed hyperthermia (axillary temperature >38^0C) at the end of the study. The mean temperature changes were -0.53^0C (SD 0.7) with highest temperature loss of 1.6^0C and highest temperature gain of 1.6^0C (Paired Student t-test; $p<0.001$*).*

Out of 43 children, 34 (79%) suffered significant body temperature loss during MRI study with mean loss of -0.79 ^{0}C (SD 0.46; range -1.6^0C to -0.1^0C). Seven (16%) children gained body temperature with mean gain of 0.57 ^{0}C (SD 0.61) and two (5%) maintained their body temperature throughout the duration of the MRI study. Out of those who had gained body temperature, two (5%) had body temperature rise by >1^0C.

Regression analysis did not show any correlation between temperature variation and age, weight or duration of MRI.

There were no complications recorded in any of the children studied during the MRI scanning and in the immediate recovery period.

DISCUSSIONS

In this study 79% of children experienced significant body temperature loss during MRI scanning with mean loss of up to 0.79 ^{0}C (SD 0.46), ranging from -1.6^{0}C to -0.1^{0}C. Approximately one-third of these children actually lost so much body temperature during the procedure as to develop clinical hypothermia at the end of the study requiring additional clinical management. Only 16% patients actually gained body temperature during the procedure with mean gain of 0.57 ^{0}C (SD 0.61, range 1.5^{0}C to 0.1^{0}C). Only a small proportion (5%) undergoing MRI scanning under general anaesthesia maintained their initial body temperature.

According to this study, maintaining body temperature balance is very unpredictable with majority of ~~in~~ children during MRI scan under general anaesthesia losing body temperature.

Anaesthetised children have the tendency to develop hypothermia due to thermoregulatory impairment and large surface area to body weight ratio. [2, 3] Also, MRI suite requires an environment with a low ambient temperature for proper functioning of magnetic coil and other the electronic equipment. This low ambient temperature of the MRI suite will further exacerbate temperature lost especially in children with low baseline axillary temperature, which in this study consisted of more than half the study population. It is known that MRI scanner uses radiofrequency waves to generate image which is absorbed by the patient resulting in heat generation. [4] The quantity of radiofrequency radiation absorbed during MRI examination is described as SAR (Specific Absorption Rate, Watts/Kg) and international guidelines limit SAR to 4W/kg over 15 min. [5] However, the amount of heat generated this way is insignificant as evident by the proportion of children who actually gained body temperature rise during MRI scanning, which is only 16% of the children in this study. The general recommendation is to maintain the core body temperature as normal as possible to prevent complications related to hypo or hyperthermia during anaesthesia and recovery period.

The ideal technique for measuring temperature should be rapid, painless, and reproducible and accurately reflect the core temperature. Hard wire thermistor or thermocouple based sensors during MRI scanning are prone to error due to the electromagnetic interference; they interfere in image quality and also gets heated up due to RFR. [15] Axillary temperature measurement using electronic thermometer is safe, rapid and painless. Both the axilla and rectum is highly accurate site for the examination of core body temperature and does not vary under variety of conditions. [12] Other studies also approved axillary temperature measurement as an alternative to core body temperature measurement. [13, 14]

There are several studies on temperature changes during MRI scanning in children under sedation or general anaesthesia. However the results have been conflicting with some showing no change, temperature loss and even temperature gain. Bryan *et al*. [6] showed that children sedated with chloral hydrate for brain MRI did not become hypothermic but rather had increased body temperature despite minimal barriers to heat loss and no active warming. A study by Machata *et al.* [7] on infants and children showed significant increase in body temperature during 1.5 and 3T MRI examinations. This increase was more profound during 3T MRI and patient heating occurred despite minimal efforts to reduce passive heat loss under sedation and without the use of warming devices. On the other hand, Isaacson *et al.* [8] concluded that clinically significant core body temperature change

is uncommon in children undergoing MRI with different magnetic field strengths, and with and without Propofol sedation. On the contrary, studies on infants and children during MRI scan under general anaesthesia show decrease in body temperature. An audit by Miller *et al*. [9] revealed that there was a statistically significant decrease in the body temperature following MRI scans under general anaesthesia in the infant age group. A study on children undergoing MRI scan under general anaesthesia by Acar *et al.* [10] also showed that body temperature was decreased in 70% patients, which is reflective of our own findings. He reported body temperature increased in 26.7%, and showed no change in 3.3% patient, which is a lot higher than our own findings. Lo *et al.* [11] suggests that more focus is needed regarding the cooling effects of GA agents during MRI, as opposed to the heating effects of the MRI scanner.

Our sample contained patients older than one year old, hence cannot be compared with Miller *et al.* [9] In the present study 3T device was used but our findings are in contrast with those of Bryan *et al.* [6] and Machata *et al.* [7] who found increase in core body temperature. Although we did show body temperature increased after the procedure but this is only a small proportion, in keeping with the findings from Acar *et al.*, which is just slightly higher. The differences may be due to devices, anaesthetic agents used and clinical condition requiring MRI scan.

There are several limitations in this study. First, there were missing data and in this case only 53% of the study population had duration of MRI study recorded. Another is the sample size which is small. Although this study has shown that there is a significant reduction in body temperature at the end of the MRI study in 79% of the children undergoing MRI scanning under GA and 30% developed clinical hypothermia, there were no clinical complications occurring due to temperature loss.

In conclusion, based on the findings of this study and information from literatures, variation in body temperature is very unpredictable during MRI scan in paediatric patients under general anaesthesia. In majority, there can be a significant reduction in body temperature at the end of the procedure in majority of the children and a rise in body temperature in the minority. Therefore anaesthetist should consider monitoring temperature throughout the scan duration if possible and take all measures to avoid significant heat loss and in those with significant heat lost, swift clinical management to raise the body temperature to normal baseline levels will alleviate any unnecessary complications from occurring.

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