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Research Article

Optimal Site for Precordial Stethoscope Placement in Pediatric Patients Younger Than Two Years: A Preliminary Cross-Sectional Study

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ABSTRACT

Background: The precordial stethoscope is a traditional and non-invasive monitoring method during pediatric general anesthesia. In this preliminary cross-sectional study, we aimed to investigate the characteristics of lung and heart sounds via precordial stethoscope and determine the optimal site for auscultation in children below 2 years of age.

Methods: This study involved 68 patients who underwent general anesthesia with tracheal intubation. Auscultation sounds via precordial stethoscope were recorded in MP3 format at the following three sites: Site A-region between the clavicle and nipple on the left midclavicular line; Site B-region between the nipple and costal arch on the left midclavicular line; and Site C-point on the left midaxillary line that was horizontally leveled with Site B. Eight blinded evaluators individually and randomly scored lung and heart sounds on a 10-point scale (0: cannot hear at all and 10: can hear clearly).

Results: Lung sound scores at Sites A, B, and C were 8.0 (7.0–9.0), 4.5 (2.9–6.0), and 7.0 (5.5–8.5), respectively, while heart sound scores at Sites A, B, and C were 3.5 (2.0–6.0), 6.5 (4.0–8.0), and 1.0 (0.4–2.0), respectively. Statistically significant differences were found in all pairs of sites.

Conclusion: We suggest that Site A, where anesthesiologists can hear both the lung and heart sounds, is the optimal site of precordial stethoscope attachment during general anesthesia for intubated children below 2 years of age.

The precordial stethoscope is a traditional and non-invasive method of monitoring heart and lung sounds and is used by anesthesiologists during pediatric general anesthesia. However, these sounds have not yet been quantitatively well-established and there is difference in opinion regarding the optimal site for precordial stethoscope placement among textbooks on pediatric anesthesia [1-2].

This study describes the characteristics of lung and heart sounds that can be heard when the precordial stethoscope is placed at various sites and aimed to determine the optimal site for auscultation in children less than 2 years old.

Methods

This was a preliminary cross-sectional study in children younger than two years who were administered general anesthesia with tracheal intubation. The study protocol was approved by the ethics Committee of our institution (Approval number: 1-6). Parental written informed consent was obtained for all participants. The inclusion criteria were 1) age less than two years and 2) requiring general anesthesia with tracheal intubation. The exclusion criteria were 1) anesthesia for emergency surgery; 2) patients with insufficient space for stethoscope attachment; and 3) patients with scoliosis or

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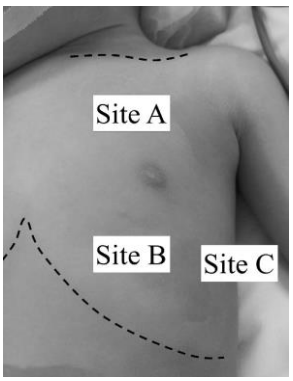
skeletal abnormalities. To the best of our knowledge, no studies have examined the relationship between the site of precordial stethoscope attachment and auscultation quality. Therefore, this study prospectively enrolled patients during one year between October 2019 and September 2020 and used data from 68 patients. Two patients were excluded because of emergency surgery.

Patients underwent tracheal intubation with either a cuffed or an un-cuffed tracheal tube after induction of general anesthesia. Bronchial and esophageal intubations were distinguished based on auscultation of bilateral lung fields and capnography. After tracheal intubation and before surgery, respiratory settings were changed as follows (only during recording): pressure-controlled ventilation; 10 mL/kg tidal volume; 20/min respiratory rate; 1.00 second inspiratory time; 5 cmH2O PEEP; and 0.30 FIO2. Larger tubes were substituted in patients with tidal volume less than 10 mL/kg that was due to leaks. Auscultation sounds were recorded in MP3 format at the following three sites (Figure 1): Site A-region between the clavicle and the nipple on the left midclavicular line; Site B-region between the nipple and the costal arch on the left midclavicular line; and Site C-point on the left midaxillary line that was horizontally level with Site B. Eight blinded evaluators individually and randomly scored sorted lung and heart sounds on a 10-point scale where 0 represented 'can't hear at all' and 10 denoted 'can hear clearly'. The median of all eight scores were compared among the three sites. Clinical data, such as the age, gender, height, body weight, and size of the cuffed or un-cuffed tracheal tube, were collected from medical and anesthesia records.

Data were analyzed using the GraphPad Prism software program, ver. 9 (GraphPad Software, San Diego, CA, USA). Continuous data are presented as median (interquartile range), and categorical data are presented as counts (%), as appropriate. Friedman's test was used to compare scores for auscultation sounds among the three groups, followed by Dunn's multiple comparison as the post-hoc test; $p < 0.05$ was considered statistically significant.

Figure 1- The three sites for recording

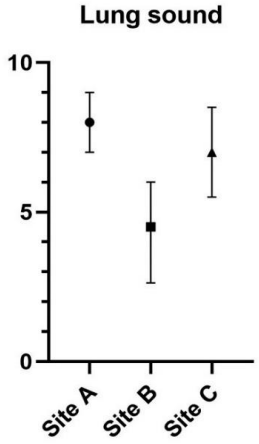


Results

The cohort had a median age of 12 (6–17) months and consisted of 46 (68%) males. Median height was 72.5 (64.4–78.3) cm and median weight was 8.8 (6.8–10.0) kg. Median tracheal tube diameter was 3.5 (3.5–4.0) mm and 38 patients (56%) were provided a cuffed tracheal tube.

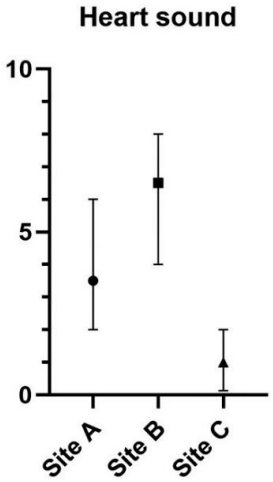
Lung sound scores at Sites A, B, and C were 8.0 (7.0–9.0), 4.5 (2.9–6.0), and 7.0 (5.5–8.5), respectively (Figure 2).

Figure 2- The quantitative analysis of lung sounds (0: cannot hear at all and 10: can hear clearly)



On the other hand, heart sound scores at Sites A, B, and C were 3.5 (2.0–6.0), 6.5 (4.0–8.0) and 1.0 (0.4–2.0), respectively (Figure 3). Statistically significant differences were found in all pairs of sites ($p < 0.0001$ for all except for Site A vs. C for lung sounds [$p = 0.0107$] and Site A vs. B for heart sounds [$p = 0.0018$]).

Figure 3- The quantitative analysis of heart sounds (0: cannot hear at all and 10: can hear clearly).



Discussion

The results of this study quantitatively show that, in intubated under two-year-old children, Site A, i.e., the region between the clavicle and the nipple on the left midclavicular line, was most suitable for detecting lung sounds, while Site B, i.e., the region between the nipple and the costal arch on the left midclavicular line, was most suitable for detecting heart sounds. Notably, while previous reports have indicated the suprasternal notch [1] or the left sternal border between the second and fourth interspaces (above nipple line) [2] to be suitable for auscultation of lung and heart sounds, these results were not quantitative. Further, auscultation at the suprasternal notch may lead to inadvertent failure in noticing right mainstem intubation. Additionally, we consider Site A to be more suitable for auscultation during general anesthesia than Site B because it is our opinion that lung sounds are more important than heart sounds during pediatric general anesthesia for the following two reasons. First, lung sounds are crucial for monitoring airway patency during both anesthesia induction and emergence, when the reliability of capnography is lower than the maintenance phase of general anesthesia. Second, assessment of cardiac output based on heart sounds via a precordial stethoscope is non-quantitative and heart rate can be effectively monitored by other devices, such as a pulse oximeter and an electrocardiogram. Thus, our results imply that auscultation at Site A can improve safety during pediatric general anesthesia.

This study has three limitations. First, we did not compare auscultation quality between Site A and the region defined by left sternal border between the second and fourth interspaces (above the nipple line), even though the latter site has previously been reported as suitable. This is because the chest wall at Site A is flat and provides easy attachment for a precordial stethoscope, thus making it suitable for clinical use. Additionally, as our chosen Site A is close to the region previously defined as suitable, similar results can be expected. Second, we only enrolled intubated children who were less than two years old. Further studies that analyze auscultation sounds in non-intubated children, neonates, and children older than two years are needed. Third, this study is a preliminary cross-sectional study, and based on our results, we would like to perform a prospective study to identify the optimal site for precordial stethoscope attachment.

Conclusion

We suggest that, during general anesthesia, Site A, i.e., the region between the clavicle and nipple on the left midclavicular line, is the optimal site of precordial stethoscope attachment in intubated children who are under two years of age.

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