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REPORTS OF ORIGINAL INVESTIGATIONS

Unexplained fever after bilateral superficial cervical block in children undergoing cochlear implantation: an observational study

Fièvre inexpliquée après bloc cervical superficiel bilatéral chez des enfants subissant une implantation cochléaire: une étude observationnelle

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Abstract

Purpose *In an effort to decrease postoperative opioid requirements, intraoperative bilateral superficial cervical plexus block (BSCPB) was recently adopted for all our children undergoing general anesthesia for bilateral simultaneous cochlear implantation (BSiCI). Several cases of early postoperative fever were noted after the adoption of BSCPB. Our aim was to determine if an association exists between BSCPB and early postoperative fever in children undergoing BSiCI. As a secondary outcome, we studied the efficacy of BSCPB in altering postoperative analgesic requirements.*

Methods *We conducted a retrospective cohort study of 91 consecutive children who underwent BSiCI. The series included 34 patients who received BSCPB (Block Group) and 57 patients who did not receive BSCPB (No-block Group).*

Results *The median age (range) was 15.4 months (eight months - 15 yr). A significant association was found between BSCPB and postoperative fever ($P = 0.006$). Eighteen (19.7%) children developed fever in the first 24 hr after surgery (Block Group: 12/34 [35%]; No-block Group: 6/57 [11%]; $P = 0.006$). The Block Group was 4.8 times more likely to develop early postoperative fever after adjusting for other variables ($P = 0.004$). The Block Group spent more days in hospital after surgery compared with the No-block Group ($P = 0.043$). Other vital signs showed no major deviation from the normal ranges, and daily physical examinations revealed no obvious source of infection in children who developed postoperative fever.*

Conclusion *Bilateral superficial cervical plexus block may increase the risk of postoperative fever in children undergoing BSiCI. In this series, BSCPB was associated with a longer hospital admission. The etiology of the fever is undetermined, although it can be hypothesized that BSCPB resulted in unintended block of the phrenic nerves leading to diaphragmatic paralysis, atelectasis, and early postoperative fever in young children.*

Résumé

Objectif *Dans un effort visant à diminuer les besoins postopératoires en morphiniques, le bloc bilatéral peropératoire du plexus cervical superficiel (BSCPB) a été récemment adopté pour tous les enfants ayant une anesthésie générale pour implantation cochléaire bilatérale simultanée (BSiCI). Plusieurs cas de fièvre postopératoire précoce ont été constatés après l'adoption du BSCPB. Notre but était de déterminer s'il existe une association entre le BSCPB et la fièvre postopératoire précoce chez des enfants subissant une BSiCI. Nous avons également étudié comme critère d'évaluation secondaire l'efficacité du BSCPB à modifier les besoins en analgésiques postopératoires.*

Méthodes *Nous avons mené une étude de cohorte rétrospective sur 91 enfants consécutifs subissant une BSiCI. La série a inclus 34 patients qui avaient eu un*

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BSCPB (groupe « bloc ») et 57 patients n'ayant pas eu de BSCPB (groupe « sans bloc »).

Résultats *L'âge médian était de 15,4 mois (extrêmes: huit mois - 15 ans). Une association significative a été trouvée entre le BSCPB et la fièvre postopératoire ($p = 0,006$). Dix-huit (19,7 %) enfants ont présenté une fièvre au cours des 24 premières heures suivant l'intervention (groupe bloc: 12/34 [35 %]; Groupe sans bloc: 6/57 [11 %]; $p = 0,006$). La survenue d'une fièvre précoce postopératoire a été 4,8 fois plus probable dans le groupe bloc après ajustement pour les autres variables ($p = 0,004$). Le nombre de jours d'hospitalisation après l'intervention a été plus important pour les patients du groupe bloc que pour les patients du groupe sans bloc ($p = 0,043$). Les autres signes vitaux n'ont pas présenté d'écarts majeurs par rapport aux valeurs normales et les examens physiques quotidiens n'ont révélé aucun foyer évident d'infection chez les enfants ayant développé une fièvre postopératoire.*

Conclusion *Un bloc bilatéral du plexus cervical superficiel peut augmenter le risque de fièvre postopératoire chez les enfants subissant une BSiCI. Dans cette série, le BSCPB a été associé à une plus longue durée d'hospitalisation. L'étiologie de la fièvre est indéterminée bien que l'on puisse émettre l'hypothèse que le BSCPB a engendré un bloc non intentionnel des nerfs phréniques, responsable d'une paralysie diaphragmatique, d'une atélectasie et d'une fièvre postopératoire précoce chez de jeunes enfants.*

Regional anesthetic techniques are commonly used to reduce postoperative pain related to the surgical site. Bilateral superficial cervical plexus block (BSCPB) is reported to reduce postoperative pain and analgesic requirements after adult thyroid and carotid surgery.[1-3] Bilateral superficial cervical plexus block may also reduce postoperative analgesic requirements in children undergoing ear surgery.[4,5]

A review of our experience with cochlear implantation identified a greater postoperative opioid consumption in children undergoing bilateral simultaneous cochlear implantation (BSiCI) when compared with children undergoing unilateral implants, and a suspicion arose that the greater analgesic requirement was a reflection of increased postoperative pain.[6] In an effort to decrease the discomfort related to the implant site and possibly decrease postoperative opioid requirements, intraoperative BSCPB was recently adopted and applied to all our children undergoing general anesthesia for BSiCI. Several cases of early postoperative fever were noted after the implementation of BSCPB. Bilateral superficial cervical plexus block was the only adjustment to our BSiCI protocol, and no definitive cause for fever could be identified.

Whereas cervical plexus block is associated with specific local and systemic complications in adults, little is known about the complications associated with this regional anesthetic technique in young children. Our aim was to evaluate whether BSCPB was associated with early postoperative fever after cochlear implantation in our series. As a secondary outcome we studied the efficacy of BSCPB in altering postoperative analgesic requirements.

Methods

Data were analyzed from a retrospective cohort of 91 consecutive children undergoing BSiCI over the five-year period from 2005 to 2009 at The Hospital for Sick Children, Toronto. The Research Ethics Board at The Hospital for Sick Children, Toronto, approved the study and waived the need for informed consent. The series included 34 patients who received BSCPB (Block Group) and 57 patients who did not receive BSCPB (No-block Group). The latter group included patients who underwent surgery before BSCPB was implemented (47 patients) and after it was abandoned (ten patients). Data were collected from an electronic patient record system and were complete for all subjects. No child was excluded. Information obtained from the electronic patient record included demographics, duration of surgery, postoperative vital signs, postoperative analgesia requirements, length of hospital stay, and scanned nursing and physician's progress notes.

General anesthesia was maintained using a total intravenous technique[7] or inhalational anesthesia. The senior surgeon (B.P.) operated on all children and performed all cervical plexus blocks adhering to the technique described below. Blocks were administered after the induction of general anesthesia and before incision. A single dose of intravenous antibiotic was administered preoperatively, and oral antibiotics were prescribed for seven days postoperatively. Unless contraindicated, cephalosporins were the antibiotics of choice. All postoperative orders were entered into an electronic patient record system, and medication doses were calculated automatically based on patient weight. Following discharge from the postanesthesia care unit (PACU), acetaminophen 10 $mg \cdot kg^{-1}$ *po*, codeine 1.0 $mg \cdot kg^{-1}$ *po*, and dimenhydrinate 0.5 $mg \cdot kg^{-1} \cdot day^{-1}$ *po* (divided Q6 hourly) were ordered as needed. Body temperature was assessed every four hours via the axillary route while in the PACU and after admission to the ear, nose, and throat (ENT) ward. Fever was defined as any body temperature $> 38.0^{o}$ C. Head dressings were removed on the morning of the first postoperative day, and the surgical

site was inspected for any signs of dehiscence or infection. No blood products were administered perioperatively.

In the absence of fever, children were routinely discharged home on the first postoperative day. Febrile children had a daily full physical examination, including auscultation of the chest and examination of the intravenous and surgical sites. Patients who developed postoperative fever were discharged after their febrile episode had ceased for 24 hr.

Bilateral superficial cervical plexus block technique

Bilateral superficial cervical plexus block was performed using an anatomical landmark-based technique. The midpoint of the posterior edge of the sternocleidomastoid muscle (midpoint between the mastoid tip and the clavicular head of the muscle) was used as a landmark for injection. This roughly corresponds to the level of C3-C4. The skin over the injection site was sterilized using 2% chlorhexidine gluconate and 70% isopropyl alcohol. A 22-G needle was introduced along the posterior border of the clavicular head of the sternocleidomastoid at an angle perpendicular to the long axis of the body with a slight caudal angulation. Ultrasound was not used to guide needle placement. After an aspiration test, a single injection of 1.0 - 1.5 mL 0.25% bupivacaine with epinephrine 1: 200,000 (AstraZeneca, Mississauga, ON, Canada) was administered 0.5-1.0 cm deep to the skin (Figure). The same procedure was performed on the opposite side of the neck.

Statistical considerations

A Student's two-sample *t* test was used to compare normally distributed variables, including surgical time. A Mann-Whitney U test was used to compare non-normally distributed variables, including length of stay and dose of medications administered. A Fisher's exact test was used to compare incidences of postoperative fever. Pearson's correlation was used to test the correlation between age and weight prior to multivariable analysis, and logistic regression was used to build a model testing for potential confounders and variables associated with postoperative fever. All *P* values are two sided and considered statistically significant at values < 0.05. Statistical analysis was performed using SPSS® software v.17 (SPSS Inc, Chicago, IL, USA).

Results

The median age for our sample was 15.4 months, ranging from eight months to 15 yr. The children were American Society of Anesthesiologists' physical status class I or II. Demographic information and total surgical time were similar between groups (Table 1). Eighteen (19.7%) children developed fever in the first 24 hr after surgery, 12/34 (35%) in the Block Group and 6/57 (11%) in the No-block Group (Table 2). When comparing incidences of postoperative outcomes, there was a significant association between BSCPB and early postoperative fever (odds ratio [OR] 4.6; 95% confidence interval [CI] 1.6 to 13.5; $P = 0.006$). The association was also present when the fever threshold was decreased to $\geq 37.8°C$ ($P = 0.007$). The absolute risk increase for postoperative fever was 24.7% with a number needed to harm of 4.

The odds of having early postoperative fever were 4.8 times greater in the Block Group than in the Non-block Group after adjusting for age and total surgical time (logistic regression, 95% CI 1.65 to 13.94; $P = 0.004$). Age and weight were strongly correlated, and therefore only age was added to the final model (relative risk $[R^2] = 0.933$; $P = 0.0001$).

No patient had fever documented in the PACU records. Within the first postoperative day, fever resolved spontaneously in 14 children; on the second postoperative day, it

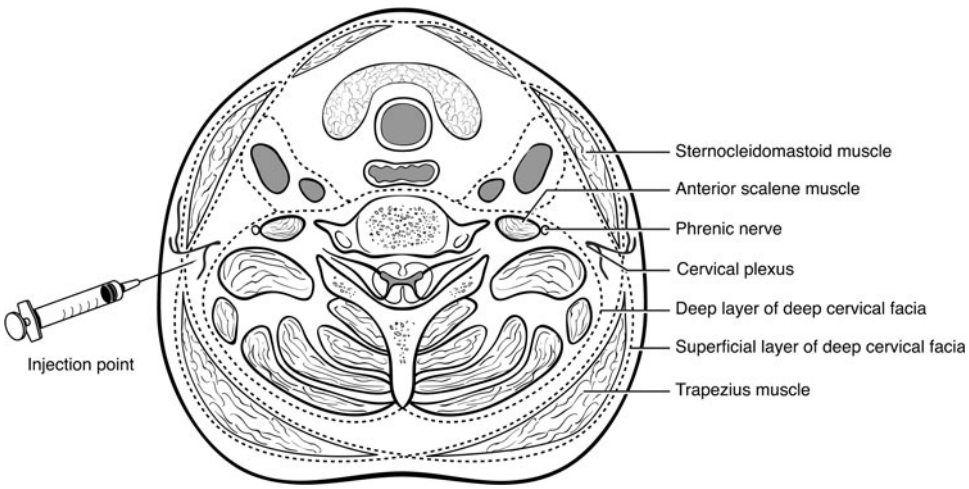

Figure A cross-sectional illustration of the neck at the level of C4 showing the different fascial layers and the site of injection

Table 1 Demographic information and total surgical time in the Block and No-block Groups

	Block ($n = 34$)	No-block ($n = 57$)	P value
Age (months)*	19.1 (12.2 - 34.1)	12.8 (11.6 - 26.8)	0.073
Weight (kg)*	11.9 (9.3 - 16.2)	10.8 (9.4 - 12.6)	0.119
Total surgical time (hr)†	5.15 (0.5)	5.22 (0.5)	0.325

*Median (percentiles 25th-75th); †Mean (standard deviation)

resolved in an additional three children, and on the third postoperative day it resolved in one child. Three of the four patients whose fever persisted beyond 24 hr were in the Block Group. Subsequently, fever was associated with a longer hospital stay in the Block Group (Table 2) (Mann-Whitney test, $P = 0.043$). All other vital signs remained largely within their respective normal ranges, and daily physical examinations revealed no obvious source of infection in children who developed postoperative fever.

There were no differences in the median doses of acetaminophen, codeine, or dimenhydrinate administered to the groups (Mann-Whitney test, $P > 0.05$). There was negative correlation between the total dose of acetaminophen and age ($R^2 = -0.227$; $P = 0.031$), but no significant correlation was observed between total codeine dose and age ($R^2 = -0.171$; $P > 0.05$). On further analysis, the median dose of codeine required by children older than three years was lower than their younger counterparts (Mann-Whitney test, $P = 0.001$).

Discussion

This observational study shows a strong association between BSCPB and early postoperative fever. The odds of having early postoperative fever were 4.8 times greater in the Block Group than in the No-block Group, and subsequently, fever was associated with increased hospital length of stay.

Given our standardized postoperative care protocols, the absence of an indwelling catheter, lack of signs and symptoms of wound infection or deep vein thrombosis, and the fact that fever in all cases developed within the first 24 hr after surgery, it is hypothesized that fever developed from atelectasis secondary to phrenic nerve and diaphragmatic paralysis. Atelectasis was not confirmed by chest *x-rays*; rather, it was a diagnosis of exclusion. Two mechanisms are postulated. After injection, the local anesthetic may have penetrated the deep layer of the deep cervical fascia and inadvertently blocked the phrenic nerve, leading to diaphragmatic paresis and atelectasis. Alternatively, the local anesthetic could have been injected unintentionally directly into the deep cervical space, again resulting in an unintended block of the ipsilateral phrenic nerve.

Phrenic nerve paralysis is a side effect of various types of cervical and brachial plexus block because the nerves have roots in common.[8] The cervical plexus arises from the anterior rami of C2-4 while the phrenic nerve arises from C3-5. Interscalene block is commonly associated with decreased diaphragmatic motion and pulmonary function when tested by ultrasonography and spirometry, repectively.[9-11] The duration of diaphragmatic paralysis is variable, lasting from 75 min to four hours depending on the type of cervical block and whether epinephrine is used in combination with the local anesthetic.[8,12] Superficial cervical block, unlike the deep block, carries a low risk of complications related to nerve paralysis.[13] In a systematic review comparing superficial to deep cervical block in adults undergoing carotid endarterectomy, more than 2,500 cases of superficial cervical block were reviewed and no serious complications, including respiratory distress secondary to diaphragmatic or vocal cord paralysis, were recorded.[14]

In a cadaveric study, Pandit *et al.* examined patterns of injectate spread after different cervical blocks.[15] Methylene blue was injected into the superficial cervical space in four cadavers, just under the investing cervical fascia (superficial cervical block). Post-injection anatomical dissection revealed methylene blue beneath the deep cervical fascia in all four cadavers, and the dye was found to surround both the cervical nerve roots and the phrenic nerve. A control cadaver was injected subcutaneously (superficial to the investing fascia), and dissection revealed that the dye remained in the subcutaneous tissue.

The likelihood of phrenic nerve block may be greater in infants and young children compared with adults given the closer proximity of the phrenic nerve to the injection site in

Table 2 Incidence of fever and length of stay in the Block and No-block Groups

	Block ($n = 34$)	No-block ($n = 57$)	P value
Incidence of fever (%)*	12/34 (35.3%)	6/57 (10.5%)	0.006†§
Length of hospital stay‡ (days)	2 (1.0-2.5)	1(1.0-1.0)	0.043§

*Frequency; †Relative risk (RR) = 3.33; 95% confidence interval = 1.42 to 7.80; Absolute risk difference = 24.7%; Number needed to harm = 4.0 (Note: odds ratio was used for interpretation in the Results and Discussion). ‡Median (25th - 75th percentile). §Statistically significant difference detected between groups

this population. However, it is unknown whether the relatively small volumes (1.0-1.5 mL) injected deep to the skin are sufficient to cause significant phrenic nerve block in infants and young children.

In this series of patients, the local anesthetic is believed to have been injected into the superficial cervical space where it subsequently penetrated the deep cervical fascia and thereby entered the deep cervical space (Figure). This might be expected in a pediatric population due to their less fibrous and more delicate fascia. We cannot exclude the possibility of having injected the local anesthetic unintentionally directly into the deep cervical space, as the superficial cervical space is a potential space, and close proximity exists between the different layers of the cervical fascias. The above mechanisms of phrenic nerve block are hypotheses based on different experimental studies, and we re-enforce that the mechanism of fever in our series remains undetermined.

The current series was drawn from a consecutive cohort of patients who were eligible for BSiCI; however, the study was non-randomized and non-blinded. A consecutive sample within the cohort received the intervention. Both groups showed close homogeneity. We note that our study establishes association, and not causation, between BSCPB and early postoperative fever. All data were collected from an electronic charting system. The exposure and outcome data were complete for all patients and were recorded accurately in the electronic system. Unfortunately, a dose-response relationship cannot be established as the exact dose of the local anesthetic injected in each case was not accurately documented.

We interpret the data for analgesic requirement cautiously. Analgesic medications were prescribed as needed, allowing for inter-individual variability in drug administration. Our analysis revealed no significant difference in the analgesic doses provided to both groups, and the nurses were unaware of BSCPB implementation and the patients who received it. The lower analgesic consumption in children older than three years can be explained by their ability to better express their levels of pain. Possible over-medication of the younger age group could have acted as a negative confounder, thus diminishing the effect of BSCPB on analgesic requirements. Another analgesic aspect to be considered is acetaminophen's known ability to mask fever; however, there was no significant difference in the dose of acetaminophen administered to the groups. The mean dose of acetaminophen used in our series was 3.3 (2.1) doses per patient, which is insufficient to mask fever for 24 hr.[16]

There have been several recent advancements in techniques for administering regional anesthesia. For example, ultrasound guidance has been shown to decrease both the volume of local anesthetic required and the incidence of diaphragmatic paralysis associated with cervical blocks in adults.[17,18] Further studies will determine whether this holds true for children. Using surface anatomical landmarks and standard volumes of local anesthetics, we found that the odds of acquiring early postoperative fever with BSiCI were 4.8 times greater when BSCPB was administered, and fever was associated subsequently with a longer hospital length of stay.

In conclusion, while we support the use of ultrasound guidance for children receiving BSCPB, bilateral blocks are associated with longer hospital length of stay, and the efficacy of BSCPB to reduce postoperative analgesic requirements following cochlear implantation is uncertain.

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Competing interests None declared.

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