Clinical anatomy of the maxillary nerve block in pediatric patients

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Abstract

Anatomical landmarks in children are mostly extrapolated from studies in adults. Despite this, complex regional anesthetic procedures are frequently performed on pediatric patients. Sophisticated imaging techniques are available but the exact position, course and/or relationships of the structures are best understood with appropriate anatomical dissections. Maxillary nerve blocks are being used for peri-operative analgesia after cleft palate repair in infants. However, the best approach for blocking the maxillary nerve in pediatric patients has yet to be established.

In an attempt to define an optimal approach for maxillary nerve block in this age group three approaches were simulated and compared on 10 dried pediatric skulls as well as 30 dissected pediatric cadavers. The needle course, including depth and angles, to block the maxillary nerve, as it exits the skull at the foramen rotundum within the pterygopalatine fossa, was measured and compared. Two groups were studied: Group 1 consisted of skulls and cadavers of neonates (0–28 days after birth) and Group 2 consisted of skulls and cadavers from 28 days to one year after birth.

No statistically significant difference ($p > 0.05$) was found between the left and right side of each skull or cadaver. Only technique B, the suprazygomatic approach from the frontozygomatic

angle towards the pterygopalatine fossa, exhibited no statistical significance ($p > 0.05$) when other measurements made on the skulls and cadavers were compared. Technique A, a suprazygomatic approach from the midpoint on the lateral border of the orbit, as well as technique C, an infrazygomatic approach with an entry at a point on a vertical line extending along the lateral orbit wall, showed statistical significant differences when measurements of the skulls and cadavers were compared.

On the basis of these findings technique B produces the most consistent data for age groups 1 and 2 and supports the clinical findings recently reported.

Key words: Regional anesthesia; Head and neck nerve blocks; Trigeminal nerve block; Suprazygomatic approach

Background

Cleft lip and/or palate are considered to be the most frequently encountered craniofacial malformation (1), with a worldwide incidence of approximately 1 in 1000 live births (2-4). Congenital cleft palate repair is ideally performed in the first year of life. The surgery is also considered to be an extremely painful procedure, with the most significant pain experienced in the early postoperative period (5, 6).

Regional anesthesia has a number of advantages and can provide postoperative analgesia in infants and neonates, without the risk of respiratory depression (7). Maxillary nerve block within the pterygopalatine fossa can provide sensory blockade of the hard and soft palate (8) and, in this way, provide intraoperative and postoperative analgesia. For the best results, the maxillary nerve needs to be blocked prior to the division of the greater palatine nerve at the location of the foramen rotundum or within the pterygopalatine fossa. The nerve is shielded by the anterior border of the lateral pterygoid plate, superiorly and laterally, as it exits from this foramen (9). The optimal location for a maxillary nerve block is therefore within the pterygopalatine fossa.

A maxillary nerve block can be considered efficient, simple and safe and improves patient comfort and postoperative analgesia according to Mesnil and co-workers (10). Although several techniques to block the maxillary nerve have been described (10-12), this is the first study to evaluate this block in pediatric cadavers, according to the authors.

This study evaluates the anatomy of three different approaches to the maxillary nerve block in neonatal and infant cadavers with the aim of establishing the most effective method of blocking the maxillary nerve within the pterygopalatine fossa in this age group.

Methods

Three approaches to the maxillary nerve block were chosen based on a review of the literature. The following criteria were used to select the three techniques:

- newly developed (technique A, has not been evaluated yet)

- most commonly performed (technique B is the most described method in the literature)

- easily comparable (technique C is performed in the same plane and therefore easy to compare to technique A and B).

These techniques were then simulated on 10 dried pediatric skulls and 30 formalin fixed dissected pediatric cadavers within the Department of Anatomy, University of Pretoria, South Africa and conducted according to the Declaration of Helsinki. All cadavers and skulls were legally obtained (according to the South African National Health Act, Act 61 of 2003) and stored in the Department of Anatomy for research and teaching purposes. Ethical clearance to perform this study on the sample of neonatal cadavers was obtained from the Faculty of Health Sciences Research Ethics Committee of the University of Pretoria.

Needles were inserted into the pterygopalatine fossa using the guidelines set out for the three techniques (as described in the paragraphs prior to figure 2, 3 and 4 respectively). Two of the techniques were suprazygomatic approaches (technique A and technique B) while technique C was an infrazygomatic approach. The sample was divided into two age groups: Group 1 consisted of

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skulls and cadavers of neonates (0–28 days after birth) and Group 2 consisted of the infant skulls and cadavers from 28 days to one year of age. Seven neonatal skulls and 25 neonatal cadavers were measured in Group 1, while three pediatric skulls and five cadavers were measured in Group 2. All three techniques were simulated on both sides of each skull and cadaver. High quality digital photographs were then taken from a superior, anterior and lateral view and subsequently imported into an image analysis program called UTHSCSA Image Tool Version 3. The needle depth and angles to enter the pterygopalatine fossa were then measured and tabulated. The depth was measured from the zygomatic process of the maxillary bone.

From an anterior view, the plane perpendicular with the median plane was considered to be 0°. If the needle is angled superiorly towards the pterygopalatine fossa, it will be considered as an increase (+) in the angle while any inferior angling of the needle will be a decrease (-) (Fig. 1A). From a superior view, the perpendicular plane was again considered to be 0° with any anterior deviation seen as an increase (+) and any posterior deviation as a decrease (-) in the angle (Fig.1B).

Figure 1: (A) Anterior view and (B) superior views of the pediatric skull indicating the superior / inferior and anterior / posterior angles of the needle, respectively

All measurements for the left and right sides (left *vs.* right) and the dry skulls and cadavers (skulls *vs.* cadavers) were compared. The skull measurements were seen as the "ideal" values based on the "visibility" of the pterygopalatine fossa and ease of needle insertion. In contrast, the cadaver measurements were considered to be the "real" values as they more accurately simulated the clinical setting. A technique was considered to be effective if no difference existed between the cadaver ("real") and skull ("ideal") measurements.

In technique A (Fig. 2A & B) the needle was placed adjacent to the lateral orbital wall at the midpoint of the orbital opening. The needle was advanced in an inferior direction to reach the pterygopalatine fossa (12).
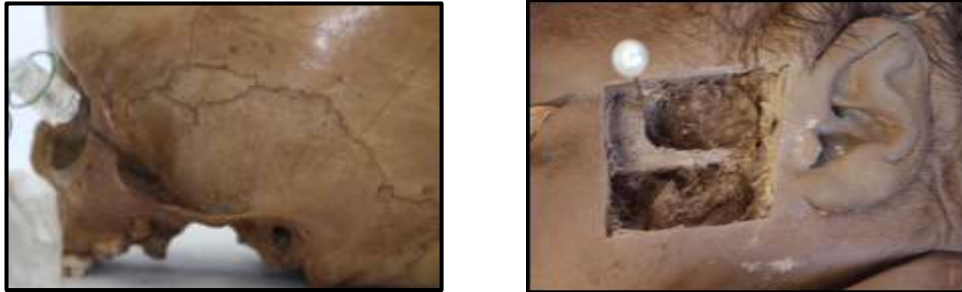

Figure 2: Technique A simulated on (A) a pediatric skull and (B) cadaver

In technique B (Fig. 3A & B), the needle was placed at the frontozygomatic angle and then advanced medially until the pterygopalatine fossa was reached (10).

Figure 3: Technique B simulated on (A) a pediatric skull and (B) cadaver

In technique C (Fig. 4A & B) the needle was inserted through the cheek at a point where a vertical line, extending along the lateral orbital wall, intersected with a horizontal line that ran perpendicular to the lateral aspect of the inferior surface of the zygomatic process of the maxilla (11).
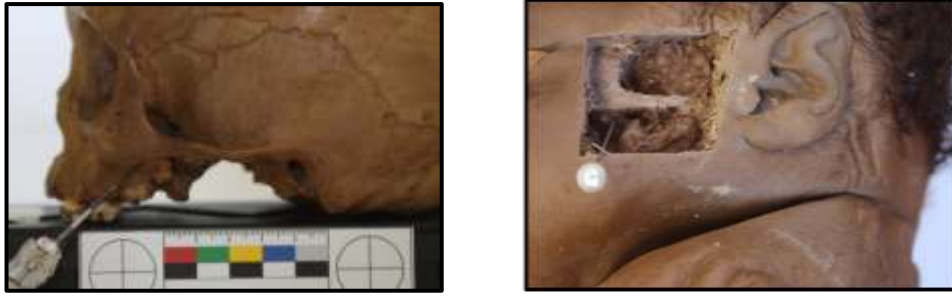
Figure 4: Technique C simulated on (A) a pediatric skull and (B) cadaver

Results

No statistically significant differences (p > 0.05; paired t-test) were found between the left and right sides of either the skulls or the cadavers for all three techniques. The sample size for each technique was therefore doubled by the combination of the results, as seen in Table 1.

Table 1: Overall results obtained for pediatric skulls and cadavers, for Group 1 and 2.

	Measurements of pediatric skulls																	
	Age group 1									Age group 2								
	Technique A			Technique B			Technique C			Technique A			Technique B			Technique C		
	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)
n	14	14	14	14	14	14	14	14	14	6	6	6	6	6	6	6	6	6
Mean	13.80	16.20	24.40	0.73	13.21	22.34	-26.80	24.25	21.42	13.93	12.43	32.73	-3.25	9.06	31.48	-28.72	23.37	34.77
SD	6.33	8.50	6.11	4.83	7.74	7.04	9.05	7.99	6.70	2.28	5.48	6.14	2.38	6.15	6.48	4.62	5.20	3.66
CI95%	3.31	4.45	3.20	2.53	4.06	3.69	4.74	4.18	3.51	1.82	4.38	4.91	1.90	4.92	5.18	3.70	4.16	2.93
Lower	10.48	11.74	21.20	-1.80	9.16	18.65	-31.54	20.06	17.91	12.11	8.05	27.82	-5.15	4.14	26.29	-32.42	19.21	31.84
Upper	17.11	20.65	27.60	3.26	17.27	26.02	-22.06	28.43	24.93	15.76	16.82	37.64	-1.35	13.98	36.66	-25.02	27.53	37.70

	Measurements of pediatric cadavers																	
	Age group 1									Age group 2								
	Technique A			Technique B			Technique C			Technique A			Technique B			Technique C		
	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)
N	50	50	50	50	50	50	50	50	50	10	10	10	10	10	10	10	10	10
Mean	20.03	12.13	21.60	0.07	12.91	21.10	-32.53	27.04	21.33	24.97	12.13	27.74	2.50	12.06	26.74	-31.17	26.53	28.55
SD	5.47	5.73	3.36	6.90	4.67	3.07	9.70	9.00	3.24	8.53	4.10	3.01	6.34	6.27	4.53	6.12	5.78	2.74
CI95%	1.52	1.59	0.93	1.91	1.29	0.85	2.69	2.49	0.90	5.29	2.54	1.87	3.93	3.89	2.81	3.79	3.58	1.70
Lower	18.51	10.54	20.66	-1.84	11.62	20.25	-35.22	24.54	20.44	19.68	9.59	25.87	-1.42	8.18	23.94	-34.96	22.95	26.86
Upper	21.55	13.72	22.53	1.98	14.21	21.95	-29.85	29.53	22.23	30.26	14.67	29.61	6.43	15.95	29.55	-27.37	30.11	30.25

CI95%: Confidence Interval of 95%
Lower: Lower range of values with a 95% confidence level
Upper: Upper range of values with a 95% confidence level
Negative (-) value with relation to superior – inferior angle indicates that the needle is entered from an inferior
    angle and proceded superiorly.

The following measurements were obtained for Group 1 on the dried pediatric skulls: For technique A, the needle was advanced for 24.40mm at a superior angle of 13.80° and an anterior

angle of 16.20°; the needle was advanced 22.34mm for technique B at an almost horizontal level of 0.73° and from an anterior direction with an angle of 13.21°. In technique C, the needle had to be inserted at an inferior angle of 26.80°, which meant that the needle was advanced in a superior direction for 24.14mm at an anterior angle of 24.25°.

The average distance that the needle was advanced to reach the pterygopalatine fossa in the dried paediatric skulls, in Group 2, for technique A was 32.73mm. The needle was directed at a superior angle of 13.93° and from an anterior direction, at an angle of 12.43°. Technique B and C both had a negative angle with regard to the superior-inferior angle. Therefore, in both techniques the needle had to be advanced in an upward direction of 3.25° and 28.72° respectively, while the anterior angles were 9.06° and 23.37° respectively.

The following measurements were obtained for the Group 1 in the cadaveric specimens. The distance that the needle had to be inserted to reach the pterygopalatine fossa was very similar for the three techniques. These distances were on average, 21.6mm for technique A, 21.1mm for technique B and 21.33mm for technique C. The anterior-posterior angles for procedure A and B were also similar. Both had to be inserted from an anterior direction at angles of 12.13° and 12.91° respectively. Technique C had a much greater anterior angle of 27.04°. The superior-inferior angles differed greatly. These angles were on average at a downward angle of 20.03°, an almost horizontal angle of 0.07° and an upward angle of 32.53° for techniques A, B and C respectively

The measurements for the cadavers in Group 2 followed a similar pattern as for those in Group 1. The pterygopalatine fossa was slightly deeper while the distance differed only slightly between technique A (27.74mm), technique B (26.74mm) and technique C (28.55mm) ($p < 0.05$). The anterior-posterior angles for technique A and B differed greatly from those of technique C. There was a large variation between the superior-inferior angles that represented the differences in needle direction when progressed into the pterygopalatine fossa. In technique A the needle was advanced at a downward direction, at an angle of 24.97°, while in technique B the needle was inserted almost horizontally at an angle of 2.5° and in technique C the needle was advanced in a more superior or upward direction at an angle of 31.17°.

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On the basis of the standard deviation and confidence interval analysis, the measurements obtained on both the dry skull and cadaver samples were compared. Technique A exhibited a statistical difference ($p < 0.05$; paired t-test) in both groups 1 and 2, when comparing the superior-inferior angle of the needle between the values of the skulls and the cadavers, whereas in Technique C a statistical difference ($p < 0.05$; paired t-test) was found when the depth to the pterygopalatine fossa in Group 2 was compared between the skulls and the cadavers. Technique B showed no statistical significance in both age groups when comparing the skulls to the cadavers. Consequently, the measurements of the angles and depth to the maxillary nerve at the foramen rotundum within the pterygopalatine fossa were combined, as seen in Table 2.

Table 2: Overall sample for technique B, results from Group 1 and 2 combined

	Age group 1			Age group 2		
	Sup – Inf (°)	Ant – Post (°)	Depth (mm)	Sup – Inf (°)	Ant – Post (°)	Depth (mm)
n	64	64	64	16	16	16
Mean	0.21	12.98	21.37	0.35	10.94	28.52
SD	6.48	5.42	4.22	5.85	6.20	5.65
CI95%	1.59	1.33	1.03	2.87	3.04	2.77
Lower	-1.37	11.65	20.34	-2.52	7.90	25.75
Upper	1.80	14.30	22.41	3.21	13.98	31.28

When technique B is used, the needle can be advanced horizontally for approximately 20mm in neonatal patients and 30mm for patients younger than one year. The needle should be advanced in a posterior direction, by just 'walking' or 'sliding' off the posterior border of the maxilla. The needle should be angled approximately 8 - 15°, at a point just anterior to the tragus of the contralateral external ear, to reach the pterygopalatine fossa. The following layers will be traversed by the needle towards the pterygopalatine fossa:

- Skin
- Subcutaneous fat and fascia
- Superficial layer of temporalis muscle
- Deep layer of the temporalis muscle including the temporal fat pad
  located between the layers of the temporalis muscle and

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- Portion of fat pad continuous with the buccal fat pad.

It's important to identify the superficial fat pad, since accidental injection of anesthetic into it may cause fat necrosis (13).

Discussion

Maxillary nerve blocks are being used for peri-operative analgesia after cleft palate repair in infants. Nerve blocks can dramatically reduce the consumption of opioid for postoperative pain relief (10). However, the best approach for blocking the maxillary nerve in pediatric patients has yet to be established.

Technique A was found to be more difficult to simulate because the bony landmarks were difficult to palpate on the cadavers. This may explain the significant difference in angles in comparing the procedure on the skulls and the cadavers.

The depth to the pterygopalatine fossa using the infrazygomatic approach, technique C, was statistically different in Group 2. This was not surprising since there was more soft tissue to transverse in the cadavers.

The bony landmarks in technique B were more superficial and could be easily palpated. No statistical difference (p > 0.05) was observed when comparing the skull and cadaver measurements for either age group.

The results of this study show that technique B is the easiest and most reliable method of blocking the maxillary nerve, which corresponds with several other studies (10, 14, 15). Stajčić and Todorović (14) suggest that this technique is the safest approach and endorse this method since this approach reaches only the anterior part of the pterygopalatine fossa, which will prevent the needle from passing into the infra-orbital fissure and potentially damaging the infra-orbital contents.

Mesnil and co-workers (10) evaluated the effectiveness of a bilateral suprazygomatic maxillary nerve block. The needle was inserted perpendicular to the skin, and advanced approximately 20mm to reach the greater wing of the sphenoid. The needle was then redirected and advanced 35mm – 45mm at a 20⁰ anterior and 10⁰ caudal direction toward the philtrum, to reach the pterygopalatine fossa. In this study the distance was measured from the level of the skin, unlike our study that measured from the frontozygomatic angle.

In comparison Captier and co-workers (15) studied computed tomographic (CT) scans of 55 infants to determine the distance and trajectory of a needle from the frontozygomatic angle to the greater wing of the sphenoid bone. The distance measured was 24.1mm ± 2.7mm with a trajectory of 19.3° ± 5.3° in a forward direction. These measurements are similar to those obtained in our study although there was slight variance when comparing the angles, that can be attributed to the different measuring techniques used.

A limitation of this study was the exclusion of skin tissue depth since the cadaver measurements were taken from the level of the zygomatic arch after removal of the skin during dissection. However, this bony landmark is very superficial and is easily palpated. This depth is clinically negligible and the needle can be inserted using the depth obtained from this study as a guideline.

This technique needs to be tested in a clinical setting to ensure that the measurements in terms of the angles and depths at which the needle needs to be introduced to reach the pterygopalatine fossa is sufficiently accurate in order that a successful maxillary nerve block in infants can be achieved.

In conclusion, the suprazygomatic approach from the frontozygomatic angle (technique B) produces the most consistent results in pediatric cadavers. Using this approach, the needle can be advanced horizontally for approximately 20mm in neonates and 30mm for infants younger than one year. The needle should be advanced in a posterior direction, towards a point just anterior to the tragus of the contralateral external ear (this should be approximately between 8° and 15°) to reach the

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pterygopalatine fossa. The needle can be guided into the fossa by 'walking' off the posterior aspect of the maxilla.

Ethical approval

Ethical approval to conduct dissections on a sample of neonatal cadavers within the Department of Anatomy, University of Pretoria, was obtained from the Faculty of Health Sciences Research Ethics Committee of the University of Pretoria (S128/2010). All dissections were conducted in the Department of Anatomy under the rules and regulations stipulated in the South African National Health Act, Act 61 of 2003.

Conflict of interests

None of the authors has any conflicts of interest to declare.

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