FEMORAL NERVE BLOCKS: A COMPARISON OF NEONATAL AND ADULT ANATOMY

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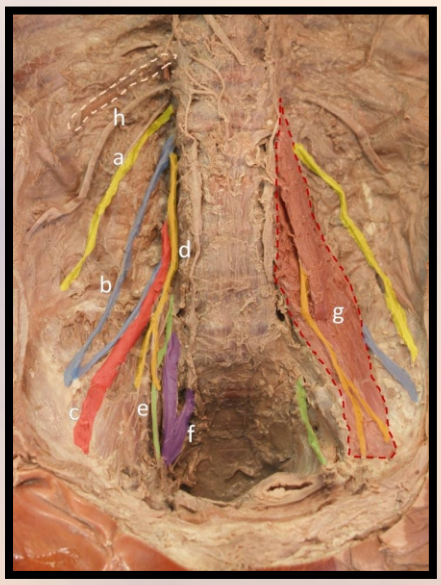
Introduction

The management of intra- and postoperative pain in children requires a rational approach, aiming to maximize both patient comfort and safety. Although it is well established that children experience pain and remember it to the same extent as adults do, adequate strategies of pain management in paediatrics and training necessary for its successful implementation are still lacking in some institutions. Although neuraxial block procedures have long been established in paediatric anaesthesia, specific nerve blocks, particularly blocks of the lower extremity, remain underused despite their excellent benefit/ risk ratio [1].

The femoral nerve (FN) is a branch of the lumbar plexus, which forms from the fusion of the ventral rami of the first four lumbar spinal nerves (L1-L4) lying on the posterior abdominal wall (see Figure 1).

Figure 1: The lumbar plexus of a neonate, consisting of the (a) ilio-inguinal and iliohypogastric nerves (yellow), (b) the lateral femoral cutaneous nerve (blue), (c) the FN (red), (d) the genitofemoral nerve (orange), (e) obturator nerve (green) and (f) the lumbosacral trunk that will form part of the sacral plexus (purple). The psoas major muscle (g) is indicated by the red dashed line. The 12th rib is indicated by the cream dashed line and subcostal nerve is also marked (h).



Successfully blocking the FN relies on injecting the local anaesthetic in close proximity to it as it enters femoral triangle, posterior to the inguinal ligament, deep to the iliac fascia (covering the iliopsoas muscle) and lateral to the femoral artery (FA). The FN block is well established as a peripheral nerve block in adult patients. The mistake however, would be to immediately assume that the position of the contents of the femoral triangle is exactly the same in neonates as in adults.

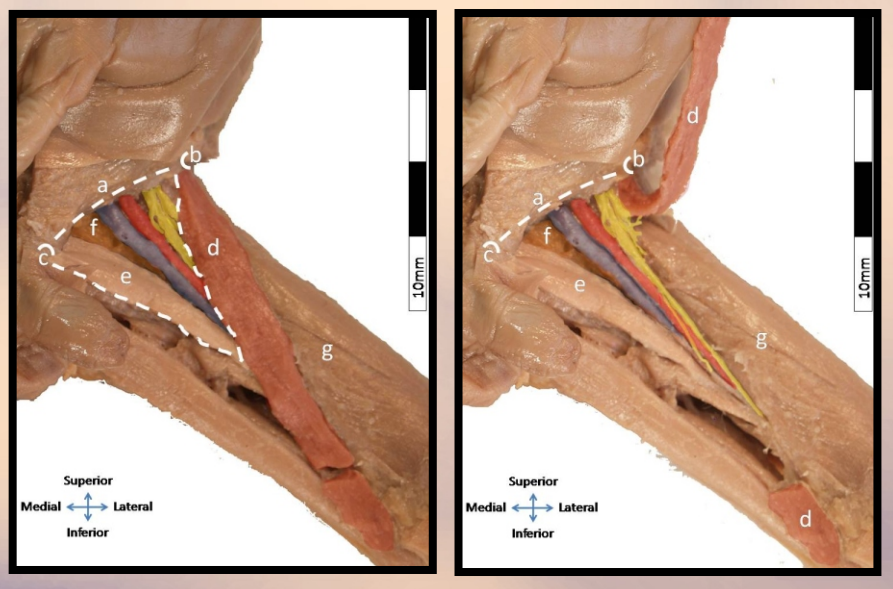
Aim

The aim of this study was to compare the positions of the neonatal FN and FA, within the femoral triangle, to the position of the adult FN and FA.

Materials and Methods

The skin and subcutaneous fat covering the anterior abdominal wall and femoral triangle was reflected on each side of 54 neonatal (50 left and 50 right; mean length: 0.44m ± 0.08m; mean weight: 1.96kg ± 1.57kg) and 77 adult (70 left and 68 right; mean length: 1.69m ± 0.09m; mean weight: 56.43kg ± 15.53kg) cadavers. After exposing the content of the femoral triangle (see Figure 2a & b), needles were inserted into the anterior superior iliac spine (ASIS) and pubic tubercle (PT), as well as into the centre of the FN and FA, at a point directly inferior to the inguinal ligament just as these structures pass posterior to the ligament.

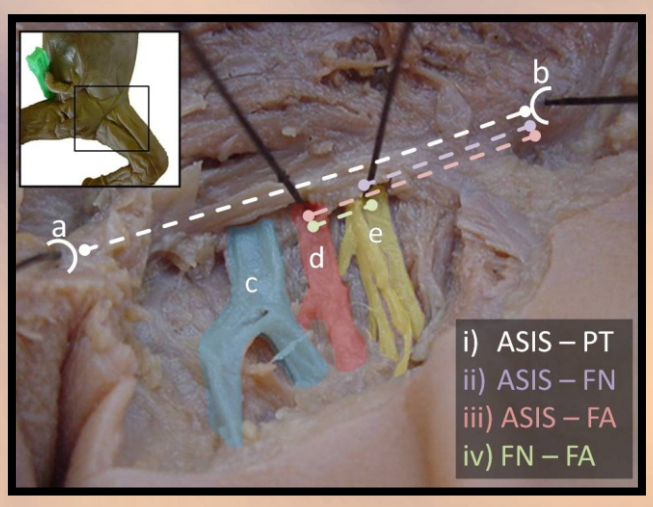
Figure 2a: The femoral triangle (indicated by the white dashed line) dissected in order to expose its content in a neonate. From lateral to medial, the FN (highlighted in yellow), FA (red) and femoral vein (blue) is visible. Also visible is (a) the inguinal ligament, (b) the ASIS, (c) the PT, and the (d) sartorius, (e) adductor longus, (f) pectineus, and (g) quadriceps femoris muscles.
Figure 2b: The sartorius muscle is reflected to show the structures travelling within the adductor canal, i.e., the FA and femoral vein, nerve branches to the quadriceps femoris muscle and the saphenous nerve.



Four separate measurements (i-iv) were then taken on both the left and right sides of each cadaver using a mechanical dial sliding calliper (accuracy: 0.01mm) (see Figure 3). Measurements were taken from (i) the ASIS to the PT, (ii) ASIS to the FN, (iii) the ASIS to the FA, and (iv) the FN to the FA.

Figure 3: Neonatal femoral triangle with needle placed into (a) the PT, (b) the ASIS, (c) the femoral vein, (d) the FA and (d) the FN. Dotted line indicates the measurements that were taken.

After all measurements were takes, the distances of the FN (ii) and FA (iii) to the ASIS was converted to a percentage of the ASIS-PT distance (i).This allowed for determining at what point (as a percentage of the ASIS-PT distance) the FN and FA passes posterior to the inguinal ligament to enter the femoral triangle. Using the percentage also allowed for comparing the results obtained in the neonatal sample with those obtained in the adult sample.



Results

A paired t-test revealed no significant difference ($p > 0.05$ for all measurements) between the left and right sides of either the neonates or adults. The left and right sides were therefore combined for the neonatal (total n = 100 femoral triangles) and adult (total n = 138 femoral triangles) samples. The results of both samples are summarised in Tables 1 and 2.

Table 1: Measurements for the total neonatal sample

	Height	Weight	Total sample ASIS-PT (i)	ASIS-FN (ii)	ASIS-FN % (ii)	ASIS-FA (iii)	ASIS-FA % (iii)	FA-FN (iv)
n			100					
Mean	0.44	1.96	30.94	11.05	34.84	14.89	48.32	3.72
SD	0.08	1.57	7.47	3.44	7.44	4.04	6.73	1.70
Min.	0.32	0.60	16.69	5.46	16.87	8.56	32.31	0.54
Max.	0.76	9.10	59.35	22.83	51.38	30.60	64.32	9.53
CI 95%			1.46	0.67	1.46	0.79	1.32	0.33
Lower			29.48	10.38	33.38	14.10	47.00	3.39
Upper			32.41	11.73	36.30	15.68	49.64	4.06

Key:
CI 95%: Confidence interval with a 95% confidence level
Lower: Lower range of the Confidence interval with a level of confidence of 95%
Upper: Upper range of the Confidence interval with a level of confidence of 95%

Table 2: Measurements for the total adult sample

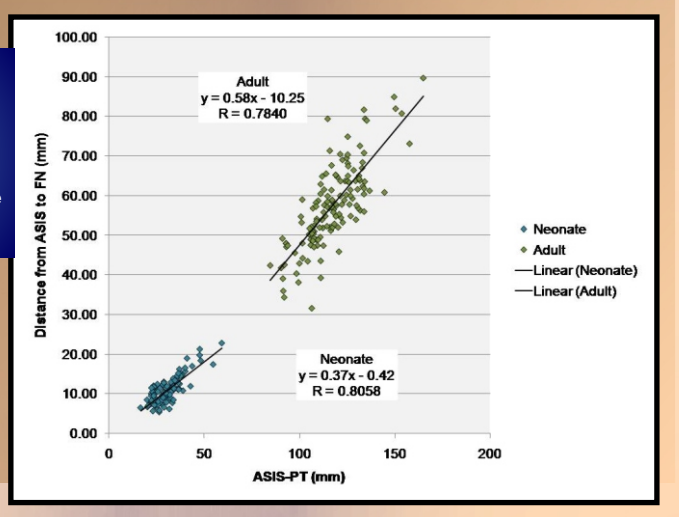
	Height	Weight	Total sample ASIS-PT (i)	ASIS-FN (ii)	ASIS-FN % (ii)	ASIS-FA (iii)	ASIS-FA % (iii)	FA-FN (iv)
n			138					
Mean	1.69	56.22	117.09	57.54	49.01	68.99	58.87	11.84
SD	0.09	15.13	14.22	10.50	5.68	10.74	5.28	3.51
Min	1.47	31.70	84.63	31.71	29.81	46.26	43.44	4.31
Max	1.92	104.70	164.85	89.81	69.30	100.79	76.64	22.97
CI 95%			2.37	1.75	0.95	1.79	0.88	0.59
Lower			114.72	55.78	48.06	67.19	57.99	11.25
Upper			119.46	59.29	49.96	70.78	59.75	12.42

A Pearson's correlation test (this test determines the strength of the linear relationship between two variables, with a value more than 0.7 indicating a strong correlation) revealed that the only strong correlation between dependant and independent variables existed between distance of the FN to ASIS (dependant variable) and the ASIS-PT distance (independent variable). This strong correlation between the above-mentioned two variables was found in both the neonatal ($R = 0.8058$) and adult ($R = 0.7840$) samples.

Discussion

Converting the measurements of both the distances of the FN and FA to the ASIS, to a percentage of the total ASIS-PT distance means that these percentages could be compared between adults (where the distances, in mm, were understandably greater in the adults than in the neonates). The percentages, along the inguinal ligament, where the FN and FA enter the femoral triangle for both the adult and neonatal samples were compared using a paired t-test. When comparing the neonatal and adult samples, there were found to be a statistically significant difference between the position of the FN ($p = 0.0000$) and FA ($p = 0.0000$) within the femoral triangle.
Because there is a statistically significant difference between the neonatal and adult data and because of the strong correlation, two separate linear regression formulae were developed for determining the distance of the FN from the ASIS in a neonatal and adult sample (see Figure 3).

Figure 4: Linear regression formulae, for both the neonatal and adult sample, plotted on graph, with the distance of the femoral nerve from the ASIS, as the dependent variable, and the ASIS-PT distance as the independent variable.



Performing a femoral nerve block on neonates is entirely different to performing it on adults. Anatomical variations, particularly in developing children, as well as differences in the depth and position of peripheral nerves, makes regional anaesthetic procedures performed on children more difficult. Fascial sheets are thinner and identifying loss of resistance more difficult [2]. It is also well known that paediatric patients, especially neonates and infants, are at greater risk of complications during the performance of regional anaesthetic procedures when compared to adults [3].

Conclusion

This study therefore shows that there are a significant difference between neonates and adults when comparing the position of the FN and FA within the femoral triangle. This fact should be carefully noted by anaesthesiologists performing femoral nerve blocks in young infants.

References

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