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## The effect of volume of local anaesthetic on the anatomical spread of caudal block in children age 1-7 years

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# Pediatric Anesthesia

## The effect of volume of local anaesthetic on the anatomical spread of caudal block in children age 1-7 years

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Re :  
PAN-2010-0285.R1, entitled "The effect of volume of local anaesthetic on the anatomical spread of caudal block in children age 1-7 years"

The enclosed manuscript has been read and approved by all authors, it is not under active consideration for publication elsewhere, has not been accepted for publication, nor has it been published in full or in part (except in abstract form)



Mark Thomas  
9<sup>th</sup> August 2010

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6 of caudal block in children age 1-7 years  
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11 M L Thomas<sup>1\*</sup>, D Roebuck<sup>2</sup>, C Yule<sup>1</sup> and R F Howard<sup>1</sup>  
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## Abstract

### Objectives

To examine the anatomical spread of caudal local anaesthetic solution in children age 1-7 years.

### Aim

To determine whether incremental increases in the volume of caudal injections of 0.5, 0.75 and 1.0 ml/kg result in reliable (>90%) and potentially clinically significant increases in the number of vertebral segments reached.

### Background

Caudal block is one of the most frequently performed paediatric regional analgesic techniques. Traditional formulae suggest that changes in the volume of caudal injectate in the range 0.5-1.0 ml/kg would have clinically useful effects.

### Methods

In a single blind design, 45 children age 1-7 years undergoing caudal block received one of three pre-determined volumes (0.5, 0.75 and 1 ml/Kg) of local anaesthetic solution containing radio-opaque contrast under controlled conditions. Following X-ray examination, the anatomical spread of the block was reported by a radiologist blinded to the volume of solution received.

## Results

There were 15 children in each group, they were similar in terms of age, height and weight. Spread was observed between the 5<sup>th</sup> Lumbar (L5) and 12<sup>th</sup> Thoracic (T12) vertebral levels. 1 ml/Kg results in a small but significantly greater spread of solution than 0.5 ml/Kg ( $p < 0.05$ ), but there was no difference between 0.5 and 0.75ml or between 0.75 and 1.0ml. No volume reliably reached a level higher than the second lumbar vertebra (L2).

## Conclusions

Incrementally increasing the volume of injectate between 0.5 and 1.0 results in a modest increase in spread of the caudal solution. It is unlikely that volumes of less than 1ml will reliably reach a vertebral level that is higher than L2.

Keywords: Anaesthetic techniques, regional, caudal, paediatric, anatomy.

## Introduction

Caudal epidural block is one of the most popular regional analgesic techniques performed in children(1, 2). The extent of analgesia following epidural blockade with local anaesthesia is dependant on the anatomical spread of solution within the epidural space, this in turn depends on the volume injected(3, 4). Physical and developmental factors also influence the spread of a given volume of solution and because of this a number of predictive formulae of varying complexity have been devised in order to predict the required volume for different circumstances; it has been suggested that analgesia reaching to T10 or above can be obtained with only 0.7-1.0 ml/Kg by some authors, but much higher volumes have been recommended by others(3, 5-8). However, we are not aware of any studies directly examining the anatomical spread of volumes less than 1ml/kg.

## Materials and Methods

45 ASA 1-2 children aged between 1 and 7 years scheduled for elective surgery with a caudal block as part of their normal anaesthetic plan were recruited. Sample size calculation was based on detecting a 2 vertebral level difference between incremental volumes with an 80% power and a significance level of  $P < 0.05$ . The study was approved by the local ethics committee and the study was performed according to the declaration of Helsinki. Parental consent was obtained and child assent sought and obtained when appropriate. 15 children were allocated to each of the three caudal volume groups. **In general**, for perineal/lower limb surgery 0.5 ml/kg was used, for groin surgery 0.75 ml/Kg, and those children scheduled for higher abdominal surgery received 1 ml/Kg: children were allocated to the appropriate group based on the operation for which they were scheduled. **The slight variability in the allocation of surgery type to each group reflects difference of opinion that exists between the relationship of the height of the block to the volume of caudal used.**

The local anaesthetic solution was made up just prior to administration by adding 1 ml Omnipaque® 300 mg I/ml X-ray contrast medium to every 9 ml of 0.25% bupivacaine. This solution was well mixed prior to administration. This resulted in a 0.225% solution of bupivacaine containing 30 mg I/ml of Omnipaque®. Omnipaque (300 mg I/ml) has been shown to be chemically compatible with bupivacaine 0.25% and 0.125% at room temperature(9). The pH of the 0.25% solution was 7.1 and the osmolality 370 mOsm/kg. Thus the



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3 solutions used met the requirements for epidurography, furthermore  
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6 Omnipaque has a long clinical history of safe use in studies on both caudal  
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8 and epidural injection.  
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11 The caudal was administered via a 22G abbocath® intravenous catheter with  
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13 the child in the left lateral position. The catheter was placed by a Consultant  
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15 Paediatric Anaesthetist in the conventional manner under aseptic conditions  
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17 once the child was anaesthetised. An Alaris Asena® infusion pump delivered  
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19 the pre-determined dose of caudal injectate at a standard rate of 600 ml/hr  
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22 (i.e. 1 ml/6sec).  
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25 A single lateral X-ray was taken upon positioning the patient on the operating  
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27 table. The gonadal region of the patient was shielded so as to minimise the X-  
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29 ray exposure (the dose of radiation required represents less than half the  
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31 expected annual exposure to a member of the public, parents were explicitly  
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33 made aware of this risk during the consent process). A single Consultant  
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35 Radiologist (DR), blinded to the volume administered, reported the extent of  
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37 spread as the highest whole vertebral level visualised (fig 1).  
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41 Patient weight, height, age and the time from caudal injection to X-ray were  
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43 recorded. Results were analysed using GraphPad Prism 5® for windows.  
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46 Parametric data were analysed using t-tests ± ANOVA as appropriate.  
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49 Kruskal-Wallis with Dunn's Multiple comparison test was used to compare the  
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51 3 volume groups.  
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## Results

Demographic variables between children in the three groups were similar in terms of age, weight, height and the time from caudal injection to X-ray, as shown in Table 1. A typical X-ray obtained following caudal injection containing radio-opaque dye with the dark column of dye clearly visible in the epidural space is shown in Figure 1.

The number of blocks reaching a given vertebral height for each volume group is shown in Table 2, the proportion for each group is given in parenthesis. The highest vertebral level achieved in at least 90% of subjects in each of the 3 volume groups is shown in Figure 2; this was L2 for 1ml/kg and L3 for both 0.75 and 0.5ml/kg respectively. The difference between 0.5ml and 1.0ml/kg was statistically significant ( $P<0.01$ ).

Table 3 shows the types of surgery allocated, on clinical grounds, to each of the volume groups.

Table 4 shows the median  $\pm$  SEM height of spread of caudal solution. There was no statistically significant difference between incremental groups but a statistically significant difference ( $p<0.01$ ) between the 0.5 and the 1 ml/kg groups.

## Discussion

This study shows that increasing the volume of caudal injectate in the range 0.5-1.0ml/kg (100% increase) has only a modest effect on the anatomical spread of the solution in the epidural space. This small increase may also be of little clinical significance as even when the volume is doubled from 0.5 ml/kg to 1 ml/kg the anatomical spread can only be reliably increased by 1 vertebral level, from L3 to L2 in the group of children we studied, well below the 10<sup>th</sup> thoracic (T10) vertebral level supplying the dermatome that includes the umbilicus. Although a simple and memorable formula based on weight has obvious advantages, a disadvantage may be that when applied to a general clinical population other important variables are ignored, thereby reducing its predictive accuracy. It is known that a number of factors, including weight, influence the spread of caudal solutions and mathematical formulae using weight, age and height have been devised to predict the correct volume. Satayoshi and Kamiyama suggest that the distance from C7 to the sacral hiatus in cm (D) is related to the desired volume (V) to clinically block to T4 by the formula  $V=D-13(10)$ . Weight was found to be a greater predictor of spread of analgesia in very young patients having caudals whereas age was a better guide in older children in the study by Busoni and Andreuccetti on 763 children(8). Schulte-Steinberg et. al. proposed a predictive formula in ml per dermatome to be blocked on the basis of age, this group found their formula to hold true for younger children aged 0-4 years as well as for older children

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3 up to the age of 12; although predicted volumes were relatively small using  
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5 this method the authors suggested that on the basis of an efficacy model  
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7 clinical analgesia several segments higher than the actual level of solution  
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9 might be expected (5).

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12 Allocation of patients to their respective volume group by type of surgery  
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14 rather than by chance should not introduce any bias. Had we set out to  
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16 determine the clinical efficacy of the block as an outcome measure then  
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18 clearly one might unwittingly assign more painful surgeries to the higher  
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20 volume groups, for example. However we were simply interested in the  
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22 physical spread of the caudal solution as our primary outcome and since this  
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24 was measured before surgery commenced, should be independent of the  
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26 intended operation.  
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32 The relationship between anatomical height of caudal solution and the extent  
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34 of analgesia is not fully understood. We did not attempt to measure clinical  
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36 efficacy of the caudal block in this study as it is notoriously difficult to  
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38 accurately measure the extent of a regional sensory block in anaesthetised  
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40 children. However, in clinical practice the aim is always to achieve reliable  
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42 spread of the solution to the vertebral level corresponding to the required  
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44 nerve root supply. Indeed, studies that have compared the efficacy low  
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46 volume high concentration caudal injections with high volume low  
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48 concentration techniques have tended to favour higher volumes, this implies  
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50 that spread of the solution to the required level is desirable (3, 11).  
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55 There are several reasons why our results might reflect a lower height of  
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57 block spread than the traditional formulae would predict. At approximately 10  
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59 minutes post injection (when the X-ray image was obtained), the caudal  
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3 solution may still be creeping cranially and not yet have reached its highest  
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5 level. Also, there may be 'pharmacological spread' that is not visible to the  
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7 naked eye on X-ray examination, representing significant numbers of local  
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9 anaesthetic molecules reaching higher vertebral levels.  
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12 Hong et al (3) provides an interesting comparison to our study in that their 1  
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14 ml/kg group reached a median height of T11, only 1 vertebral level higher  
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16 than our median for the 1ml/kg group, with their range being T8-L2. This is not  
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18 incompatible with our findings. What we are stressing is that to choose a  
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20 mean height block as the intended dermatomal cover is to condemn half the  
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22 children (by definition of the mean) in that group to a block lower than the  
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24 mean and thus potentially to a painful experience.  
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29 The 90<sup>th</sup> centile is at L2 in our study and thus 2 vertebral levels lower than the  
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31 median. Essentially we are suggesting that when it comes to a potentially  
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33 painful dermatome it is better to be 90% sure of reaching it than 50%.  
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36 Whilst there may be a statistically significant difference between the 0.5 and  
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38 1 ml/kg groups, a difference of only one vertebral level is unlikely to be  
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40 clinically significant unless the surgical site happens to span those  
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42 dermatomes.  
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47 In conclusion, we found that in order to be confident that the L2 vertebral level  
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49 is reached in 90% of cases in a group of children aged from 1-7 years, then a  
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51 volume of at least 1ml/kg is required.  
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3 Acknowledgements  
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6 Figure 1. A typical X-ray obtained with the radio-opaque dye clearly visible  
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8 within the epidural space.  
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13 Figure 1  
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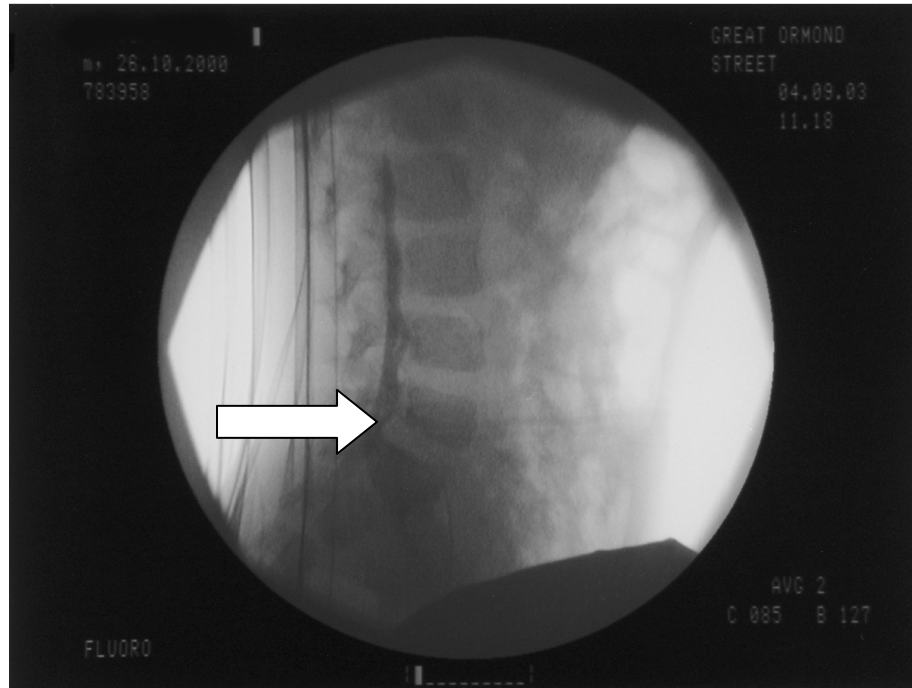
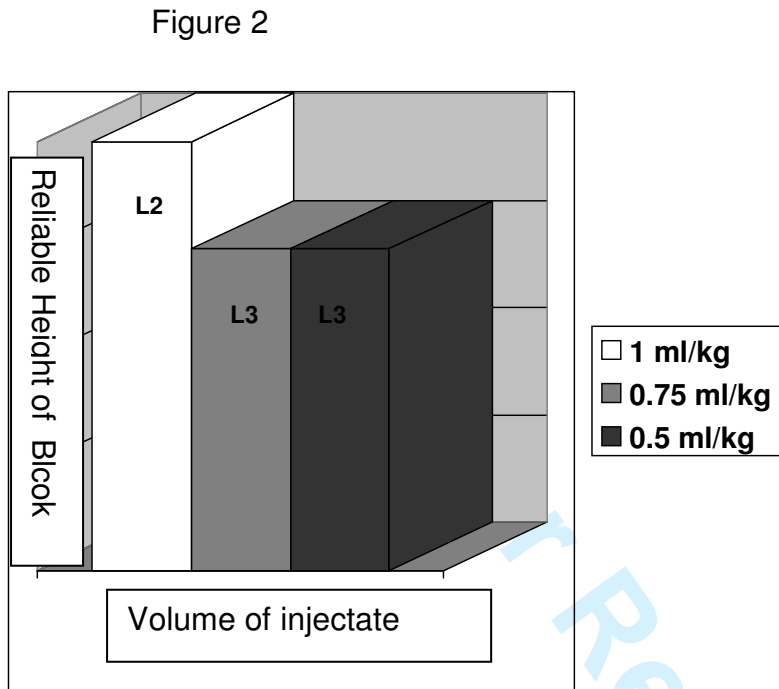


Figure 2. Vertebral level reliably obtained (>90% of caudals) for 1, 0.75 and 0.5ml/kg.



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Table 1 Demographics of each group by height, weight, age and time from injection to X-ray.

Table 1

Volume (ml/Kg)	Mean height (cms) $\pm$ SD	Mean weight (Kg) $\pm$ SD	Mean age (Years) $\pm$ SD	Time (mins) from Caudal injection to X-ray
0.5 (n=15)	102 $\pm$ 11.47	14.60 $\pm$ 3.36	3.51 $\pm$ 1.27	11.47 $\pm$ 6.9
0.75 (n=15)	95 $\pm$ 14.50	14.53 $\pm$ 4.36	2.74 $\pm$ 1.33	11.00 $\pm$ 4.2
1.0 (n=15)	104 $\pm$ 13.30	15.73 $\pm$ 3.73	3.55 $\pm$ 1.80	11.87 $\pm$ 3.9

Table 2. The number of blocks and proportion in each group achieving vertebral levels in the range L4-T12.

Table 2

Vertebral level	Volume	0.5 ml/kg	0.75 ml/kg	1 ml/kg
		(n=15)	(n=15)	(n=15)
T12		2 (13%)	2 (13%)	5 (33%)
L1		2 (13%)	6 (40%)	8 (53%)
L2		4 (27%)	10 (67%)	14 (93%)
L3		14 (93%)	14 (93%)	15 (100%)
L4		15 (100%)	15 (100%)	15 (100%)

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Table 3 The different types of surgery allocated, clinically, to each of the caudal volume groups

Table 3

Volume of Caudal (ml/kg)	Type of surgery
0.5	Wire removal (foot), circumcision (x8), hypospadias (x2), ureteric re-implant, excision glans cyst, anal dilatation, injection bladder neck.
0.75	Inguinal hernia (x2), orchidopexy (x6), hypospadias (x4), club foot, circumcision, release buried penis.
1	Pyeloplasty (x3), hypospadias (x5), orchidopexy (x5), inguinal hernia, left hip metalwork removal.

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3 Table 4 shows the median  $\pm$  SEM height of anatomical spread for each  
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6 caudal volume.  
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9  
10 Table 4

Caudal Volume (ml/Kg) n=15 in each group	Median $\pm$ SEM Height of anatomical spread of caudal volume
0.5	L2 $\pm$ 0.44
0.75	L1 $\pm$ 0.32
1	T12 $\pm$ 0.43

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