Correspondence

Risk factors for apnea after infant inguinal hernia repair

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SIR—We read with interest the letter by Kim *et al.* describing their experience with apnea and hernia repair in infants (1). We have also performed a retrospective audit, and given the paucity of published data, wish to present our findings which reinforce many of Kim *et al.*'s conclusions. The aim of our audit was to determine risk factors for spinal anesthesia failure and postoperative apnea. After approval from our Human Research Ethics Office we searched our theatre database to identify infants aged <1 year of age who had hernia repair between 1 July, 2006 and 31 December, 2006.

We identified 129 infants. Records were missing for two infants. Of the rest, 91 had planned general anesthesia (GA), 29 had successful spinal anesthesia with no supplemental sedation apart from oral glucose and seven had unsatisfactory spinal anesthesia requiring sedation or conversion to GA. Of the seven in the unsatisfactory spinal anesthesia group, two spinals were abandoned because of total failure while five required only brief supplemental sedation.

The gestational age at birth, postmenstrual age (PMA) and weight for each anesthesia group are shown in Table 1. Spinals tended to be attempted in children with lower weight, PMA and gestational age at birth, but there was considerable overlap between groups.

In two cases, spinal failures were because of inexperience, in one case because of a bloody tap and for four babies there was no obvious reason for failure. Analyzing the 36 babies where spinal anesthesia was attempted and taking failed spinal as the outcome, a logistic regression found no association between failure and PMA, gestation at birth, weight and dose of local anesthetic. However, the numbers are small, so weak associations cannot be ruled out.

Apnea was defined as any apnea observed and recorded in the patient record, irrespective of duration or heart rate. Apnea was defined as early if occurring within the first hour, and late if occurring in hospital after 1 h. Early apnea was not recorded in any child who had a successful spinal anesthetic, however similar to Kim *et al.* we found that in children where spinal anesthesia was unsuccessful, early apnea was particularly common (Table 2). One child had a long apnea at 21 h after an uncomplicated general anesthetic resulting in a brief unplanned admission to ICU. This child was 28 weeks gestation at birth, 41 weeks PMA and weighed 2.7 kg.

We used logistic regression analysis to define risk factors for early and late significant apnea. For the regression, intention-to-treat (GA vs intention for spinal which includes failed spinal and successful spinal) and as-per-protocol analyses (GA and unsuccessful spinal vs successful spinal) were both performed. For the logistic regression analysis, significant apnea was defined as any baby having an apnea apart from those who had a single untreated apnea that required no intervention and was not associated with desaturation.

By logistic regression with an intention-to-treat analysis, there was no evidence for an association between significant early apnea and PMA, gestation at birth, weight or intention for spinal anesthesia. Similarly with an as-per-protocol analysis there was no evidence for an association between significant early apnea and gestation at birth, PMA or weight; however having a successful spinal could not be entered into this particular regression as none of those with successful spinal had any early apnea. In summary for early apnea it is difficult to predict which baby will have an early apnea, but if a spinal was given and successful, then the risk can be assumed to be low and if a spinal was given and failed, the risk for early apnea is high.

For late apnea, there was weak evidence of an association between significant apnea and lower PMA ($P = 0.08$) but no association between significant late apnea and intention-to-give a spinal, gestation at birth or weight. With the as-per-protocol analysis there was also an association between significant late apnea and lower PMA but no association between significant late apnea and gestation at birth, weight or successful spinal. In summary, late apnea is more strongly associated with low PMA than type of anesthesia, gestation at birth or weight.

Table 1
Age and weight

	General (n = *91*)	*Successful spinal* (n = *21*)	*Unsuccessful spinal* (n = *7*)
Gestational age at birth (weeks)	37.09 ± 3.87 (24–40)	34.86 ± 4.27 (27–40)	34.43 ± 5.38 (27–40)
Postmenstrual age (weeks)	47.11 ± 5.58 (37.86–67.29)	42.50 ± 3.55 (34.14–49.14)	43.88 ± 3.86 (37.43–48.57)
Weight (kg)	4.48 ± 1.16 (2.30–6.60)	3.55 ± 0.92 (1.90–5.50)	4.05 ± 1.17 (2.70–5.60)

Data as mean ± SD (range).

Table 2
Apnea severity in each group

	General anesthetic	*Successful spinal*	*Unsuccessful spinal*
Early apnea			
None	85	29	4
1 Apnea with no desaturation or intervention	1	0	0
1 Apnea with desaturation or intervention	2	0	0
>1 Apnea – no intervention	1	0	1
>1 Apneas associated with desaturation or intervention	2	0	2
Major intervention	0	0	0
Late apnea			
None	86	27	7
1 Apnea with no desaturation or intervention	0	0	0
1 Apnea with desaturation or intervention	3	1	0
>1 Apnea – no intervention	0	1	0
>1 Apneas associated with desaturation or intervention	1	0	0
Major intervention	1*	0	0

Desaturation is defined as <90%.
Intervention is defined as stimulation or mask ventilation.
*Admission to ICU from ward.

There were five intra-operative complications in the GA group: one dural tap and two bloody taps with a caudal, one long apnea and one laryngospasm with laryngeal mask removal. There were no intra-operative complications in the spinal groups. Postoperatively there were three babies with prolonged hospital stay because of evidence of systemic infection (two probable respiratory tract infections and one febrile convulsion with unknown source of sepsis), and surprisingly, three were readmitted soon after discharge with evidence of systemic infection (one wound infection, one unknown source and one bronchiolitis 5 days after discharge).

This audit is not without limitations. The numbers are still relatively small, so finding no evidence for association does not rule out the possibility that weak associations may exist. Also an inherent limitation of such an observational study is that known and unknown confounding factors may influence associations. Stronger evidence for effectiveness of spinal vs GA can only be found in large randomized trials. Our audit did not electronically capture details of apnea duration and apnea was not defined in terms of duration. This is perhaps reasonable, given previous definitions are largely arbitrary. Also a recent study demonstrated that electronic apnea detection will find a substantial proportion of these children having many otherwise unrecognized apneas. This questions their clinical significance (2). For this audit we relied on the occurrence of apnea being documented and classified apnea as significant if there was a documented desaturation or intervention. We acknowledge this as a subjective and imperfect measure. Finally, we also do not routinely collect hemoglobin data so cannot comment on how this may affect apnea risk.

Our success rate for spinal anesthesia is similar to other published series. It could be made higher if spinal blocks are performed only by experienced staff. As shown previously, spinal anesthesia is an excellent technique to reduce early apnea, however children where the spinal has failed or required supplementation are at particularly high risk of apnea. This may be due to the combination of therapies or perhaps more likely because of the child's underlying status; a child who is irritable and difficult to hold or settle may be a child more likely to have apnea. Late apnea is most worrisome in terms of patient management beyond the PACU. Therefore, it is pertinent that the strongest predictor of late apnea is low PMA and that, in agreement with Kim *et al.*, spinal anesthesia may not be a guarantee of no late apnea. Lastly, the one child who had an unplanned admission to ICU had an apnea 21 h after surgery. In our institution some children would be home by then. Was this child particularly lucky not to have been discharged, or are there many apnea's happening at home that are untreated and do not result in death or morbidity? There is still much to be learnt about infant apnea after anesthesia.

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