Evaluation of the premature infant at risk for postoperative complications

James F. Mayhew MD, Denis L. Bourke MD,
Walter S. Guinee MD

We reviewed anaesthetic records of 35 infants with a history of prematurity, who presented for elective herniorrhaphy. We applied a scoring system to help evaluate risk of postoperative complications. Six patients experienced postoperative complications. All six patients had a score of five or more and gave history of either apnoea or a history of moderate bronchopulmonary dysplasia. A preoperative history of apnoea and/or moderate bronchopulmonary dysplasia appear to be valuable markers for postoperative complications. A conceptual age of 40 weeks is an acceptable lower limit of age providing there is no history of apnoea or pulmonary disease.

The incidence of congenital inguinal hernia in the premature infant has been reported to be 42 to 55 per cent.^{1,2} Reports suggest that premature infants have an increased risk of post anaesthetic complications when compared to full-term infants undergoing similar surgery.³⁻⁵ This is a review of our experience with premature infants who presented for elective herniorrhaphy. We also report an evaluation of a clinical scoring system for predicting the risk of postanaesthetic complications in this population.

Methods

With the approval of the Human Research Advisory Committee at the University of Arkansas for Medical Sciences, we retrospectively reviewed the records of 35 premature infants who had undergone elective inguinal herniorrhaphy from January 1983 to January 1985. In

Key words

INFANTS: premature; COMPLICATIONS: postoperative; ANAESTHESIA: premature infant.

From the Department of Anesthesiology, Arkansas Children's Hospital, Little Rock, Arkansas.

Address correspondence to: Dr. James F. Mayhew, City of Faith Medical and Research Center, Department of Anesthesiology, 8181 South Lewis, Tulsa, Oklahoma 74136.

reviewing the charts, each patient was evaluated and assigned a risk number using a premature risk score suggested by Oh⁶ (Table I).

We defined apnoeic spells as the cessation of breathing for longer than 20 seconds, or for a shorter period if associated with bradycardia and/or cyanosis. A history of apnoea was defined as an apnoeic episode occurring between birth and the time of anaesthesia that required either stimulation or full resuscitation to restore breathing. Moderate apnoeic spells were defined as less than two spells in the four-week period prior to anaesthesia. Severe apnoea spells were defined as two or more such episodes in the four-week period prior to anaesthesia. Moderate bronchopulmonary dysplasia (BPD) was defined as presence of x-ray evidence of bronchopulmonary dysplasia without a history of medical treatment. Severe BPD was defined as that requiring medication.

The anaesthetic record was reviewed for anaesthetic techniques and intraoperative problems which would have an influence on postoperative complications. The record for the postoperative period was examined for complications, looking specifically for respiratory and/or cardiac complications, and feeding difficulties.

The premature risk score versus the presence/absence of postoperative complications was analyzed using the Spearman correlation coefficient.

Additionally, we applied the Fisher exact probability test, dividing the patients into two groups: those with scores of four or less and those with scores of five or greater.

The following modifications were made to the scores suggested by Oh.⁶ In the original scoring system, gestational age in weeks was used at time of surgery. We modified this by looking also at the gestational age, plus the postnatal age. We found that by using the conceptual age (gestational age plus postnatal age) at surgery, we had a better estimate of age as a risk factor, since an infant with a gestational age of 28 to 30 weeks would weigh the score toward a higher risk level, but when the conceptual age is considered (gestational age plus postnatal age), the severity of the prematurity becomes a less significant factor. Thus, three patients had a gestational age of 28

TABLE I Anaesthetic risk score—premature infants*

Score	0	1	2
Apnoeic spells	None	Moderate	Severe
Birth weight (gm)	>2,500	1,500–2,500	<1,500
Gestational age (wk)	>37	30–36	<30
Haemoglobin (gm%)	>12	10–12	<10
Pulmonary disease (bronchopulmonary dysplasia)	None	Moderate	Severe

*From Oh.⁶

weeks and one a gestational age of 26 weeks, but had conceptual ages of 45 to 60 weeks. These patients had no complications, despite a higher weighted score (Table IV). Of the patients with complications, three patients had a gestational age of 28 weeks, but had conceptual ages of

37 to 41 weeks. One patient had a conceptual age of 72 weeks.

Results

All the infants in the study were inpatients. They were permitted clear oral fluids up to three hours prior to surgery, and no patient received premedication. All infants received nitrous oxide, oxygen and halothane (Table II). In addition, four received isoflurane after an induction with halothane. No infant received intraoperative narcotics. Seven infants received a neuromuscular blocking drug, pancuronium. All induction techniques included a mask induction using nitrous oxide/oxygen and halothane following which the trachea was intubated and the lungs ventilated mechanically. Following completion of the surgical procedure, the infants were

TABLE II Summary results

Patient	Ages			Drugs during anaesthesia						Score	Post-Operative Complications
	GA	PN	CN	N ₂ O	Halothane	Isoflurane	Pancuronium	Atropine	Neostigmine		
1	33	20	53	+	+	—	—	—	—	—3	
2	36	9	45	+	+	—	—	—	—	—3	
3	30	46	76	+	+	—	—	—	—	—4	
4	33	43	76	+	+	—	—	—	—	—4	
5	33	12	45	+	+	—	—	—	—	—4	
6	33	11	44	+	+	—	—	—	—	—3	
7	33	12	45	+	+	+	—	—	—	—3	
8	33	6	39	+	+	—	—	—	—	—3	
9	33	8	41	+	+	+	—	—	—	—3	
10	34	36	70	+	+	+	—	—	—	—5	
11	33	6	39	+	+	+	—	—	—	—4	
12	30	26	56	+	+	+	—	—	—	—3	
13	33	6	39	+	+	+	—	—	—	—3	
14	33	8	41	+	+	+	—	—	—	—3	
15*†	28	44	72	+	+	+	+	+	+	—7	Apnoea-ventilation
16*†	28	4	32	+	+	+	+	+	+	—7	Apnoea-ventilation
17	36	10	46	+	+	+	—	—	—	—3	
18	36	6	42	+	+	+	—	—	—	—4	
19	26	34	60	+	+	+	—	—	—	—4	
20*†	33	10	43	+	+	+	+	+	+	—6	Apnoea-ventilation
21†	28	9	37	+	+	+	—	—	—	—6	Asp. first feeding
22	31	8	39	+	+	+	—	—	—	—3	
23	34	44	78	+	+	+	—	—	—	—4	
24	34	40	74	+	+	+	—	—	—	—5	
25	36	6	42	+	+	+	—	—	—	—4	
26	36	11	47	+	+	+	—	—	—	—3	
27	28	17	45	+	+	+	—	—	—	—5	
28	30	14	44	+	—	—	+	+	+	—4	
29	32	9	41	+	+	+	—	—	—	—5	
30*	29	7	36	+	+	+	+	+	+	—6	Apnoea-ventilation
31	30	8	38	+	+	+	+	+	+	—4	
32	34	6	40	+	+	+	—	—	—	—4	Asp. first feeding
33	28	20	48	+	+	+	—	—	—	—5	
34	28	24	52	+	+	+	—	—	—	—4	
35	32	9	41	+	+	+	+	+	+	—4	

GA – Gestational Age; PN – Postnatal Age; CN – Conceptual Age.

*Apnoea. †BPD.

TABLE III Risk scores. Patients with complications

Patient	Scores					Total score	Complications
	Apnoea	Birth wt.	Gestational age/surgery	Hgb.	Pulmonary		
15	1	2	2	1	1	7	Apnoea-postop. ventilation
16	1	2	2	1	1	7	Apnoea-postop. ventilation
20	1	2	1	1	1	6	Apnoea-postop. ventilation
21	0	2	2	1	1	6	Aspirated first feeding
30	1	1	2	1	1	6	Apnoea-postop. ventilation
32	0	1	1	1	1	4	Aspirated first feeding

permitted to breathe 100 per cent oxygen through the endotracheal tube until the infant had sustained spontaneous respirations and the vital signs remained within acceptable limits. Immediately following extubation the infants were given 100 per cent oxygen. All infants who had received a neuromuscular blocking agent had the agent reversed with atropine and neostigmine at the completion of surgery. The adequacy of the reversal was judged by the leg lift, as described by Mason.⁷ All infants were then cared for in an intermediate care unit. Their cardiac and pulmonary functions were monitored using an

electrocardiograph and an apnoea monitor for at least 24 hours.

Table III lists the scores and complications. Table IV lists the scores of the patients with no postoperative complications.

Among the 35 infants, one patient had an intraoperative problem consisting of complete heart block immediately following the administration of the neostigmine. This was corrected by the administration of additional atropine. There was no postoperative complication related to this problem. Among the anaesthetic techniques and agents,

TABLE IV Risk scores. Patients with no complications

Patient	Apnoea	Birth wt.	Gestational age/surgery	Hgb	Pulmonary	Gestational age surgery (weeks)	Conceptual age	Wt./surgery (kg)	Total score
1	0	1	1	1	0	33	53	7.0	3
2	0	1	1	1	0	36	45	3.7	3
3	0	2	1	1	0	30	76	3.2	4
4	0	2	1	1	0	33	76	3.7	4
5	0	2	1	1	0	33	45	3.3	4
6	0	1	1	1	0	33	45	3.7	3
7	0	1	1	1	0	33	45	4.1	3
8	0	1	1	1	0	33	39	4.8	3
9	0	1	1	1	0	33	41	3.8	3
10	0	2	1	2	0	34	70	2.5	5
11	0	2	1	1	0	33	39	1.6	4
12	0	1	1	1	0	30	56	4.0	3
13	0	0	2	1	0	33	39	4.6	3
14	0	1	1	1	0	33	41	4.6	3
17	0	1	1	1	0	36	46	4.5	3
18	0	1	1	2	0	36	42	3.0	4
19	0	2	1	1	0	26	60	2.8	4
22	0	1	1	1	0	31	39	1.5	3
23	0	2	1	1	0	34	78	4.8	4
24	0	2	2	1	0	34	74	2.0	5
25	0	1	2	1	0	36	42	3.0	4
26	0	1	1	1	0	36	47	2.8	3
27	0	2	2	1	0	28	45	3.7	5
28	0	2	2	0	0	30	44	4.1	4
29	0	2	2	1	0	32	41	2.6	5
31	0	2	2	2	0	28	48	3.4	6
33	0	2	2	0	0	28	52	3.1	4
34	0	2	2	0	0	32	41	3.2	4
35	0	0	2	2	0	32	41	3.6	4

TABLE V Weights at time of surgery (kg)

No complication group (29)	Complication group (6)
Range 1.5–7.0	1.8 to 3.1
Mean 3.58	2.2
SEM ± 0.24	SEM ± 0.15

$p < 0.01$

only the use of a nondepolarizing muscle relaxant pancuronium was associated with an increased incidence of postoperative complications. Of the six patients who developed postoperative complications, four had received the pancuronium and needed postoperative ventilatory support. Three of the 29 patients without complications had received pancuronium and needed no postoperative ventilatory support.

Using the Spearman correlation coefficient, the association between the premature score and complications was $r_s = 0.59$ and $p < 0.001$. Among the individual risk factors the history of pulmonary disease and apnoea episodes correlated with postoperative complications.

Applying the Fisher's exact test, we were able to divide out patients into two groups: anaesthetic risk scores of five or greater was associated with a significant higher incidence of postoperative complications and those of four or less was associated with a noncomplicated postoperative course ($p < 0.0001$).

We also looked at the weight at time of surgery. The range of weight for the complicated group was 1.8 to 3.1 kg with a mean of 2.2 ± 0.15 (SEM). The range for the noncomplication group was 1.5 to 7.0 kg with a mean of 3.5 ± 0.24 (Table V). Using Student's *t* test $p < 0.01$.

Discussion

In 1982 Steward³ warned of the high incidence of postoperative complications in the premature infant. Since then at least one additional report of postoperative complications in this population has appeared.⁴

Although these infants may present with a post-birth age of three to four months, they may remain premature when their conceptual age is considered. Wellborne *et al.*⁵ used an evaluation system of postnatal age, weight and perinatal history consisting of apnoea spells, sudden infant death syndrome in the family, respiratory distress syndrome, bronchopulmonary dysplasia, seizures and pneumonia. Infants with a score greater than nine and a postnatal age of less than 44 weeks had periodic breathing postoperatively. However, in their series none had required postoperative respiratory support.

We found, as did Liu *et al.*,⁴ that the use of nondepolarizing muscle relaxants was associated with an increase in postoperative complications. Of the 29 patients who had a score of four or less with no postoperative

complications, three had received a nondepolarizing muscle relaxant, while four of the six who had had scores of five or higher had postoperative complications received a nondepolarizing muscle relaxant. All the infants in this series who had received a nondepolarizing muscle relaxant were judged to be adequately reversed by the criteria of Mason.⁶ In the report by Liu *et al.*⁴ four of six patients who had received a nondepolarizing muscle relaxant needed postoperative ventilatory support while two of seven who had a normal recovery received a nondepolarizing muscle relaxant. This is not explained in the report by Liu *et al.*⁴ and in review of our patients the infants who had received the muscle relaxants had the higher risk score; thus, it was determined to be the more ill infant who had received the muscle relaxant. It would appear that it was judged at the time that these infants could not tolerate the higher doses of halothane or isoflurane and thus the muscle relaxant was used as part of the anaesthetic regimen.

Several authors have suggested that elective surgery be avoided in children less than 44⁸ to 46⁴ weeks conceptual age. Ten of our patients, who had no complications, had conceptual ages below these suggested limits, while five of the six with complications had a conceptual age of less than 40 weeks. Review of the report by Liu *et al.*⁴ shows that none of their reported patients over 41 weeks of conceptual age had postoperative complications, provided there was no preoperative history of apnoea or pulmonary disease. As expressed by Liu *et al.*⁴ ideally infants at risk for apnoeic episodes during recovery from anaesthesia should be identified prior to anaesthesia and surgery. A scoring system for assessing risk for postoperative complications in premature infants was designed to identify these infants. Our scoring system was modified to include both the gestational age and postnatal age defined as conceptual age as a factor. As we statistically evaluated the results we found that the haemoglobin and birth weight did not influence the risk factors and that only a history of apnoea and/or pulmonary disease were significant risk markers for postoperative complications.

When weight at the time of surgery was evaluated, we found that the weight of the noncomplication group was significantly higher than the weight in the complication group. However, our smallest infant was found in the group which had no complications.

References

- 1 Harper RG, Garcia A, Sia C. Inguinal hernia: a common problem of premature infants 1000 gms or less at birth. *Pediatrics* 1975; 56: 112-5.
- 2 Rescoila RJ, Grosfeld JL. Inguinal hernia repair in the perinatal period and early infancy: clinical considerations. *J Ped Surg* 1984; 19: 832-7.
- 3 Steward DJ. Preterm infants are more prone to complications following minor surgery than are term infants. *Anesthesiology* 1982; 56: 304-6.
- 4 Liu LMP, Cote CJ, Goudsouzian NG *et al.* Life-threatening apnea in infants recovering from anesthesia. *Anesthesiology* 1983; 59: 506-10.
- 5 Welbourn LG, Ramirez N, Oh TH *et al.* Evaluation of anesthetic risks in premature infants. *Anesthesiology* 1984; 61: A417.
- 6 Oh TH. Inguinal hernia repair in premature infants. In: *Common Problems in Pediatric Anesthesia*. Stehling LC (ed.) Year Book Medical Publishers, Chicago, 1982.
- 7 Mason LJ, Betts EK. Leg lift and maximum inspiratory force, Clinical signs of neuromuscular blockade reversal in neonates and infants. *Anesthesiology* 1980; 52: 441-2.
- 8 Pascucci RC, Kurachehek SC, Kelly DH *et al.* Evaluation of respiratory patterns of infants in the perioperative period. *Anesthesiology* 1984; 61: 3A, A420.
- 9 Gregory G, Steward D. Life-threatening perioperative apnea in the "ex-premie." *Anesthesiology* 1983; 59: 495-8.

Résumé

Nous avons résumé les dossiers anesthésiques de 35 patients ayant une anamnèse de prématurité et s'étant présentés pour une herniorraphie élective. Nous avons appliqué un système de pointage aidant à évaluer le risque de complications postopératoires. Six patients ont subi des complications postopératoires. Les six patients avaient un pointage de cinq ou plus et une anamnèse d'apnée ou de dysplasie bronchopulmonaire modérée. L'apnée et/ou la dysplasie bronchopulmonaire modérée contenues dans une anamnèse préopératoire semblent être des indicateurs utiles de complications postopératoires. Un âge conceptuel de 40 semaines est la limite d'âge la plus basse qui soit acceptable pourvu qu'il n'y ait pas d'histoire d'apnée ou de maladie pulmonaire.