HYPOTENSIVE ANAESTHESIA FOR CRANIECTOMY IN INFANCY

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SUMMARY

Deliberate hypotension using halothane and controlled ventilation without positive end-expiratory pressure was employed in 18 of 30 patients undergoing craniectomy for unilateral or bilateral craniosynostosis over a 3-yr period. The technique was simple, resulted in good control of arterial pressure and diminished blood loss, and did not involve extensive monitoring or the use of potentially toxic adjuvant drugs. In the hypotensive group mean systolic arterial pressure was decreased from 92.5 to 65.0 mm Hg. Estimated blood loss was decreased from 111 to 89 ml (mean) for all ages and from 133 to 72 ml (mean) for infants between 8 and 32 weeks of age compared with the normotensive control group.

Premature closure of cranial sutures may occur in utero, resulting in a cosmetically deformed baby. Synostosis of two or more sutures may cause severe craniofacial deformity and visual and central nervous system disturbance as a result of intracranial hypertension during periods of rapid brain growth (Hanson et al., 1977). Early surgical decompression by strip craniectomy is recommended to allow for normal brain growth in cases of multiple craniosynostoses and to prevent serious cosmetic deformity in cases of single or two-suture synostosis (Freeman and Borkowf, 1962; Shillito and Matson, 1968).

Cranietomy in infancy, although usually a cosmetic operation, is not without risk. Shillito and Matson (1968) have reported mortality of 0.39% and morbidity of 14.0% in a large series of 519 patients undergoing a total of 689 operations over 33 yr.

Anaesthesia for craniectomy can be hazardous. The anaesthetist must monitor a significant blood loss (the two deaths in Shillito's series resulted from hypovolaemic cardiac arrest) and maintain an adequate airway despite lack of access to the face.

PATIENTS AND METHODS

Thirty patients undergoing craniectomy between March 1975 and April 1978 are reported. Eighteen received a deliberate hypotensive technique in an attempt to reduce total blood loss and to improve operating conditions. Twelve remained normotensive with the same anaesthetic agents. All the surgery was elective, upon infants with single or double craniosynostoses and no clinical or x-ray evidence of increased intracranial pressure.

The mean age of the normotensive group was 14.58 weeks (SD ± 8.53); mean weight 6.5 kg (SD ± 1.29). The mean age of the hypotensive group was 10.83 weeks (± 4.12); mean weight of 5.94 kg (± 0.53). The youngest patient was 3 weeks old (hypotensive group) and the oldest 32 weeks (normotensive group). The patients fasted for 4 h before operation and no premedication was given.

Patients were selected for the groups randomly. Both normotensive and hypotensive groups consisted mainly of operations involving the sagittal suture. Two operations not completely involving the sagittal suture were included in each group.

Anaesthesia was induced with halothane and an Oxford-pattern oral tracheal tube was inserted following the administration of a neuromuscular blocking drug. Ventilation was assisted initially then controlled manually using a Mapleson D circuit and a 500-ml capacity reservoir bag. Positive end-expiratory pressure (PEEP) was not employed and zero end expiratory pressure was confirmed in several cases by continuous manometric monitoring at the tracheal tube. Normothermia (continuous rectal temperature) was maintained by environmental temperature control, heating blankets and overhead heating lamps when indicated.

Systolic arterial pressure was monitored with a Doppler ultrasonic device. Lead II of the e.c.g. was displayed continuously. Blood loss was measured by weighing all sponges and using calibrated suction traps. In all instances, blood was replaced meticulously when losses exceeded 10–15% of estimated
total blood volume (80.0 ml per kg body weight). The neurosurgeons occasionally infiltrated the skin incision sites with sterile saline which did not contain a vasococtor.

Twenty-nine patients were managed in the supine position with a slight (25°) head-up tilt. One patient was moved from the supine to the prone position for correction of unilateral lambdoidal synostosis.

Anaesthesia was maintained in all infants with halothane and 40–60% nitrous oxide in oxygen. Hypotension was induced gradually and maintained with halothane alone; no adjuvant drugs were used. Lactated Ringer’s solution in 5% dextrose was administered at a rate of 5–7 ml per kg of body weight per hour. Data were analysed statistically using Student’s paired t test.

**RESULTS**

**Systolic arterial pressure.** The mean systolic arterial pressure before operation in the normotensive group was 83.5 mm Hg (SD ± 16). The mean intraoperative systolic arterial pressure in this group was 83.8 mm Hg (± 20.3). In the hypotensive group, halothane concentration was increased gradually (Ohio copper kettle vaporizers, temperature 25.0 °C) resulting in a significant decrease in mean systolic arterial pressure from 92.5 to 65.0 mm Hg (P<0.05). No arrhythmia and no significant increases in heart rate were encountered during hypotension.

**Halothane concentration.** The mean dose of halothane required to maintain normotensive surgical anaesthesia was 1.13% (±0.27). The mean dose of halothane required to produce a significant reduction in systolic arterial pressure was 1.40% (± 0.42) in patients less than 8 weeks of age (n = 6) and 1.33% (± 0.89) in patients 8 weeks of age or older (n = 12).**

**Total intraoperative blood loss.** Mean intraoperative blood loss in the normotensive group was 111 ml (± 97) and in the hypotensive group 89 ml (± 53) (P<0.05). This difference was more marked in patients 8 weeks of age and older: 133 ml (± 103) with normotensive anaesthesia and 72 ml (± 39) with hypotension (P<0.001). Three of the 18 hypotensive patients did not require transfusion as blood loss was less than 10% of the estimated preoperative blood volume. Of these three infants, the operation in only one did not involve the sagittal suture, and was confined to a single coronal closure.

**Haematological changes.** The haemoglobin concentration and hematocrit before operation in the normotensive group were 12.7 g% (± 0.9) and 36.2% (± 2.6) respectively. The respective values 24 h after operation were 11.2 g% (± 1.4) and 32.3% (± 4.1). In the hypotensive group the values before operation were 12.7 g% (± 1.4) and 36.7% (± 4.8) and the values 24 h after operation were 11.0 g% (± 1.9) and 32.1% (± 5.6).

Because of the higher concentrations of fetal haemoglobin in those patients less than 8 weeks of age, the effect of age was assessed. Infants less than 8 weeks of age had insignificantly greater haemoglobin and haematocrit values that did not alter anaesthetic management, blood loss or surgical outcome.

**Complications.** There were no deaths. One patient in the normotensive group suffered excessive blood loss (81.8% of preoperative estimated blood volume) and this was replaced as it occurred, without incident. Subsequent complete coagulation studies were normal. One patient in the hypotensive group had a wound dehiscence on the 5th day after operation and this required re-operation for débridement.

**Other observations.** Sex, familial incidence and sutures involved were studied also. No instance was there a family history of craniosynostosis. There were, however, no cases of Crouzon’s or Apert’s disease, both inheritable craniofacial diseases that also exhibit craniosynostosis. The male : female ratio was 1.7 : 1.0. Single sagittal synostosis was present in 84.2% of the males and 81.8% of the females. There were 25 infants with single sagittal craniosynostosis, the most common deformity in all reported series. There were two infants with bilateral coronal synostosis, one with unilateral coronal synostosis, one with unilateral coronal and sagittal synostosis, and one with unilateral coronal and unilateral lambdoidal synostosis.

The total estimated blood loss for craniectomy not completely involving the sagittal suture was not significantly less than that for parasagittal craniectomy in the same group.

**DISCUSSION**

In their large series, Shillito and Matson (1968) noted sagittal synostosis to be five times more common than any other type of craniosynostosis. The frequencies of single coronal and bilateral coronal closures were next and nearly equal. Other combinations were rare.

In paediatric centres, craniectomy for craniosynostosis is no longer an uncommon neurosurgical procedure in infancy. At The Children’s Hospital of Denver, craniectomy is the third most common neurosurgical procedure in infancy following ventri-
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The procedure is usually elective in an otherwise healthy infant and carries a significant risk of massive haemorrhage from dural venous sinuses and exposed bone, especially during parasagittal craniectomy (the most common procedure). Deliberate hypotension using halothane with controlled ventilation appears safe without requiring excessive doses of drug and is effective in reducing blood loss. This technique does not appear to be associated with the cardiovascular complications often encountered with the use of multiple hypotensive adjuvant drugs (McNeil et al., 1974; Salem et al., 1974).

Although it may augment induced hypotension by reduction in preload, the use of PEEP appears to be contraindicated in these patients as it may increase significantly cerebral venous pressures and promote unnecessary venous haemorrhage.

The intraoperative monitoring described for this technique is simple yet accurate and does not necessitate arterial invasion. The use of skin infiltration with adrenaline can be avoided, and blood loss observations and replacement can be accomplished accurately. Transfusion may even be avoided in some patients, especially those undergoing procedures not involving the sagittal suture.

REFERENCES

ANESTHESIE HYPOTENSIVE POUR LA CRANIECTOMIE CHEZ LES BEBES

Résumé
On a utilisé, au cours d'une période de 3 ans, sur 18 patients (sur un total de 30) subissant une craniectomie pour une craniosynostose unilatérale ou bilatérale, une technique d'hypotension délibérée à l'aide d'halothane et de ventilation contrôlée sans pression expiratoire à l'extrémité positive. Cette technique, qui est simple, a permis d'avoir un bon contrôle de la tension artérielle et de réduire les pertes de sang. Elle n'a exigé ni surveillance excessive ni l'usage de médicaments adjuvants potentiellement toxiques. Dans le groupe hypotensif, la tension artérielle systolique moyenne est tombée de 92,5 à 65 mm Hg. La perte de sang estimée a été réduite de 111 à 89 ml (en moyenne) pour tous les âges et de 133 à 72 ml (en moyenne) pour les bébés âgés de 8 à 32 semaines, ce qui par comparaison au groupe témoin normotensif.

HYPOTENSIVE ANÄSTHESIE FÜR KRANIEKTOMIE BEI KINDERN

Zusammenfassung
Beabsichtigte Hypotonie unter Verwendung von Halothan und kontrollierter Belüftung ohne positiven Endatmungsdruck wurde benutzt, um und zwar bei 18 von 30 Patienten, bei denen über einen Zeitraum von 3 Jahren wegen unilateraler oder bilateraler Craniosynostose eine Craniectomie vorgenommen wurde. Die verwendete Technik war einfach, führte zu guter Kontrollierbarkeit des arteriellen Druckes und zu verringertem Blutverlust, und erforderte keine umfassende Überwachung und keine Verwendung potentiell toxischer Hilfsdrogen. Bei der hypotensiven Gruppe verringerte sich der mittlere systolische arterielle Druck von 92,5 auf 65,0 mm Hg. Der geschätzte Blutverlust wurde von 111 auf 89 ml verringert, das ist der Mittelwert für alle Altersgruppen, und von 133 auf 72 ml, das ist der Mittelwert für Kinder zwischen 8 und 32 Wochen, verglichen mit der normotensiven Kontrollgruppe.

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SUMARIO
Se empleó hipotensión deliberada mediante la aplicación de halotano y ventilación controlada sin presión positiva y respiratoria, en 18 de 30 pacientes sometidos a craniectomía para craniosinostosis unilateral o bilateral durante un periodo de 3 años. La técnica fue sencilla y produjo buen control de la presión arterial, redujo la pérdida de sangre y no comprendió un extenso control del empleo de drogas coadyuvantes potencialmente tóxicas. En el grupo hipo-tensivo, la presión arterial sistólica media fue disminuida de 92,5 a 65,0 mm Hg. La pérdida de sangre calculada fue disminuida de 111 a 89 ml (medio) para todas las edades y de 133 a 72 ml (promedio) para los niños de 8 a 32 semanas de edad, en comparación con el grupo normotensivo de control.