

## Clinical Reports

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### Use of Controlled Hypotension for Primary Surgical Excision in an Extensively Burned Child

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The anesthetic management of patients with extensive burns is an integral part of an aggressive surgical approach to these disasters. This is a report of the use of hypotensive anesthesia in the case of a massively burned child. Controlled hypotension in burned patients has been tried previously. Middleton and Kinz<sup>1</sup> and Colebrook *et al.*<sup>2</sup> reported the use of deliberate hypotension for primary excision of burned areas.

The two factors which have limited primary excision and grafting in the management of extensive burns have been massive blood losses during operation and lack of adequate amounts of skin from the patients' donor sites. The advantages of primary excision include early elimination of necrotic tissue and the ability to cover the patient with skin to prevent massive fluid losses through the open burn wounds. These advantages are made possible by the use of immunosuppressive therapy<sup>3</sup> and skin transplantation from a donor with a close tissue match, while the use of hypotensive anesthesia minimizes blood loss during extensive primary excision.

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The three therapeutic modalities, hypotensive anesthesia, immunosuppression, and primary excision, have been demonstrated to be of life-saving value.

#### REPORT OF A CASE

A 28-month-old girl was admitted to the Shriners Burns Institute with extensive burns, estimated to cover 91 per cent of the body surface area (BSA) (80 per cent third-degree and 11 per cent deep second-degree burns), two days after her clothes caught fire. Only portions of the scalp, both feet, the distal halves of both hands, a patch of the right lateral thigh, and the right lateral upper arm were uninjured. Escharotomies were needed bilaterally on the chest, left arm, and left leg. Nursing care was carried out in the environment of a Bacteria Controlled Nursing Unit (BCNU).<sup>1</sup>

The day after admission (third post-burn day), split-thickness skin grafts were harvested from the few available donor sites (6 per cent BSA). A tourniquet was applied around the right thigh and 6 per cent of the third-degree burn was excised from the lower leg. This was covered with the previously obtained skin grafts. Ketamine was used as the anesthetic agent. The patient's weight on admission prior to intravenous therapy was 13.2 kg and her estimated blood volume was 1,056 ml (8 per cent of body weight). Weighed blood loss was 1,150 g. The patient received infusions of fresh frozen erythrocytes, 680 ml, fresh frozen plasma, 430 ml, and 5 per cent albumin solution, 375 ml (a total of 1,485 ml colloid), and Ringer's lactate solution, 250 ml.

Due to the severity of the burn, the patient's age, and the prognosis (survival rate with this degree of burn has been essentially zero), it was decided to proceed at once with skin transplantation. Of the family members tested, the patient's mother had

† This is an enclosed plastic-shielded unit through which nursing is maintained without directly touching the child. Temperature and humidity are controlled, and laminar airflow is provided.<sup>1</sup>

TABLE 1. Evaluation of Hypotensive Anesthesia

	First Operation Third Post-burn Day Normotensive Anesthesia	Second Operation Tenth Post-burn Day Hypotensive Anesthesia
Procedure and percentage of body surface area excised	Excision of full-thickness burns, 6 per cent  6 per cent BSA Harvested	Excision of full-thickness burns, 32 per cent  Grafts from Mother-Donor
Anesthesia technique	Ketamine	Halothane, N <sub>2</sub> O, controlled hypotension
Duration of operation	3 hours	4 hours, 35 minutes
Estimated blood volume	1,056 ml	1,056 ml
Measured blood loss and percentage of estimated blood volume	1,150 ml/109 per cent	600 ml/56.8 per cent
Net colloid replacement, percentage of estimated blood volume	123 per cent	58.2 per cent

the most compatible tissue type, and on the seventh post-burn day, immunosuppression therapy was begun. Azathioprine, 5-6 mg/kg, was administered orally before transplantation, 3 mg/kg for three days and 1.5 mg/kg daily thereafter for 32 days.

On the tenth post-burn day, the patient's mother was taken to the operating suite to donate skin. During general anesthesia with N<sub>2</sub>O/O<sub>2</sub> and galamine, split-thickness skin grafts were obtained from both buttocks and thighs and were transferred to a second operating suite in which the recipient had been prepared.

Under hypotensive anesthesia the child underwent primary excision of the burned eschar of the chest, abdomen, left arm, and upper thighs (approximately 32 per cent BSA). The excised area was then grafted with skin obtained from the mother-donor. The anesthetic agents were halothane, 1.2-2.5 per cent, and nitrous oxide, with no premedication. Hypotension was maintained with pentamethonium given intravenously in 2-mg increments for a total of 14 mg. The arterial blood pressure was recorded from a cannulated radial artery using a multichannel recorder. The lowest pressure was 50/30 mm Hg; the average was 60/40 mm Hg. Heart rates ranged from 124 to 168/min after induced hypotension, compared with 166/min before hypotension. With cessation of anesthesia, the blood pressure spontaneously returned to 90/60 mm Hg, and postoperatively, in the BCNU, the blood pressure was stable at 110/60 mm Hg.

The initial central venous pressure (CVP) was 6 cm H<sub>2</sub>O; the lowest was 3 cm H<sub>2</sub>O; the final

reading, taken at the end of the procedure, was 7 cm H<sub>2</sub>O.

The tympanic temperature decreased from 37°C initially to 34.5°C at the end of the procedure despite a room temperature of 30°C and the use of a warming blanket.

The total urinary output during anesthesia, which lasted 4 hours, 35 minutes, was 340 ml. During the 2 hours, 30 minutes, of controlled hypotension, urinary output was 42 ml/hr (1.3 ml/kg/hr). The measured blood loss was 600 ml, or 57 per cent of estimated blood volume. The net colloid replacement after subtracting the calculated maintenance dose was 58 per cent of estimated blood volume.

At the time of the first operation, done with normotensive anesthesia, which lasted 3 hours, measured blood loss was 1,150 ml, or 109 per cent of estimated blood volume, and net colloid replacement was 123 per cent, or more than twice the amount needed during the second operation (table 1).

During the first 36 hours postoperatively, the patient needed 90 ml/hr of colloid, 33 per cent more than prior to operation. During the same period, she continued to be febrile (highest temperature 40°C), with a heart rate of 168/min, blood pressure between 116/70 and 80/60 mm Hg, and CVP of 1-5 cm H<sub>2</sub>O.

The patient subsequently underwent 13 additional operative procedures, for which ketamine anesthesia was used. During these procedures the remainder of the third-degree burns were excised in stages and replaced immediately with skin allografts. Although allograft tissue was used as the initial visible skin covering of all third-degree burn areas excised except the autografted right leg,

§ CVP measured by water manometer.

the allograft was stepwise-replaced by autograft as donor sites regenerated and as the areas of second-degree burn healed. Ten weeks after injury, all anterior surfaces and extremities were closed with autografts, and at 14 weeks the patient was sufficiently covered with autograft to be removed from the bacteria-controlled environment. Nineteen weeks after injury, she was transferred to the reconstructive ward. She was discharged from the hospital 28 weeks after injury.

### DISCUSSION

In adult non-burned patients, controlled hypotensive anesthesia has been found to result in a 50 per cent decrease in blood loss.<sup>2-7</sup> Middleton and Kunz reported decreases of as much as 60 per cent of expected blood losses with hypotensive anesthesia during primary excision, a value similar to the blood loss of our patient (table 1). Prior to the use of deliberate hypotension for primary excision, our recorded blood losses have ranged from one to three times the blood volumes.

Induction of hypotension in non-burned children is allegedly difficult due to development of tachycardia secondary to ganglionic blockade.<sup>2</sup> This has not been our experience with 43 burned children. Heart rates of 120–160/min are common in severely burned children, and these rates tend not to change during ganglionic blockade.

Maintenance of deliberate hypotensive anesthesia requires close attention to volume replacement and inspired concentrations of halothane. Reversal of ganglionic blockade is achieved by discontinuing the halothane and allowing recovery from anesthesia. Pentamethonium has a duration of action of 45 minutes. Its action is prolonged when it is combined with halothane.

The concepts of transplantation used in the successful treatment of the patient reported here differ from those of kidney and other organ transplantations in that permanent survival of the grafts is not expected.<sup>3</sup> The term "intermediate-duration transplantation" is used to differentiate this concept further from that of the short-term use of allografts and xenografts of skin used as a biologic dressing

for the short-term protection and preparation of wounds.

The anesthetic management of a child with 91 per cent BSA burns is a rigorous exercise. Although the use of hypotensive anesthesia provides definite advantages, it also introduces further therapeutic restraints. Pre-operative volume replacement must be performed meticulously. Intraoperative monitoring must include direct recording of arterial blood pressure, sampling of arterial blood for measurement of blood gas values, and urine sampling for specific gravity, sodium and potassium concentrations. Ionized calcium must be monitored closely. In our experience plasma ionized calcium may be abnormally low prior to operation and acute hypocalcemia precipitated by small volumes of citrated plasma or commercial salt-poor albumin solution may occur during ganglionic blockade.

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