PRE AND POSTOPERATIVE CARE OF THE NEONATE

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Pre and postoperative care in the neonate is undoubtedly the most crucial aspect in survival of these unfortunate babies. Although surgical techniques are improving steadily, survival is most dependent on support of life and specific organ function. This paper will attempt to outline in some detail pre and postoperative care using patients with omphalocele and gastroschisis as models. Although other congenital anomalies require some modification in pre and postoperative care, the basic principles of life support and metabolic care of the surgical neonate are best illustrated by these patients.

At Children's Orthopedic Hospital and Medical Center in Seattle, during the past eight years we have seen 31 patients with omphaloceles and 47 with gastroschisis.

Omphalocele reportedly occurs in one in 5,000 births. Omphalocele patients have multiple congenital anomalies including cardiovascular, gastrointestinal, genitourinary, central nervous system and musculoskeletal. Thirty to 50% have serious anomalies which influence survival. Nearly all of the patients have malrotation. In our experience, the size of the defect correlates readily with the severity of the anomalies. In four patients, the omphalocele was not operated upon because of the severity of associated congenital anomalies. There were five deaths in the operated group (18%). One patient died of cardiac disease, two died of short-gut syndrome, one of renal failure and one of chronic lung disease secondary to long term respiratory therapy.

The average length of hospitalization for patients requiring Silon closure was 50 days and the average length of hyperalimentation was 33 days. Congenital anomalies included seven patients with moderate to severe cardiac problems, four with Beckwith-Wiedeman syndrome (Ref 18,20), two with trisomy 13, one patient with Potter's syndrome and VACTERL association. (Ref 21,22,23)

The Beckwith-Wiedeman syndrome described by our pathologist consists of multiple abnormalities including omphalocele, macrocuglossia and gigantism. Occasionally, these patients will exhibit hemihypertrophy, hypocalcemia and visceromegaly with predisposition to malignancy. Other features include mild microcephaly, flame nevus of the face, hyperplasia of the kidneys, pancreas and gonadal interstitial cells, cystomegaly of the adrenal cortex and a characteristic transverse carlobe fissure. (Ref 18,19,20).

The 47 gastroschisis patients, on the other hand, had many fewer anomalies. Five of them died (11%), 22 patients underwent primary closure and 25 underwent Silon closure without a significant difference in mortality. Four of the patients with gastroschisis who expired had intestinal atresia and postoperatively manifested short-gut syndrome. One patient died of renal failure. Gastroschisis reportedly occurs in one in 30,000 births; however, in our experience the anomaly is as frequent as omphalocele. The defect is to be right of the umbilicus. Postoperatively, gastrointestinal function is usually slow. Few other congenital anomalies are present.

The use of Silon chimney closure in gastroschisis is at times life-saving. However, it does prolong hospitalization, the initial stay being 34 days for patients with primary closure. Patients with staged Silon closure had an average stay of 70 days. The duration of hyperalimentation was also greatly increased. Patients with primary closure had 12 days average of hyperalimentation whereas Silon closure patients required 45 days. The prolonged hospitalization seems related to slower G.I. function.

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in the Silon treated patients. Intra gastric pressure measurements may allow safer and faster closure of the defect. (Ref 14).

In the Toronto series of 74 omphalocele patients, 26 died (34%). It was noted that seven of 79 patients had congenital heart defects and four of 79 had Beckwith-Wiedeman syndrome. In gastoschisis, 12 of 44 patients died (27%). (Ref 10)

Two other related, but unusual, abdominal wall defects are: 1) distal sternal cleft, known as Cantrell’s Pentalogy and 2) exstrophy of the cloaca. Distal sternal cleft occurs in approximately one in 150,000 births and consists of a distal sternal cleft, omphalocele anterior defect of the diaphragm, pericardial defect and intracardiac defect – most often VSD or diverticulum of the left ventricle. (Ref 4) It is often a lethal condition.

The lower abdominal defect, exstrophy of the cloaca, occurs in approximately one in 60,000 births and its major features include bladder exstrophy, vesicointestinal fissure, imperforate anus, omphalocele and double appendix. Multiple other anomalies including CNS and genitourinary produce a highly lethal condition with a mortality of approximately 80%.

PREOPERATIVE EVALUATION OF THE PATIENT WITH OMPHALOCELE OR GASTROSCHISIS

Although the omphalocele patient is most apt to have multiple anomalies, any surgical neonate should be evaluated preoperatively for cyanosis, urine production, temperature instability and hypoglycemia. In addition, it should be determined whether the baby is term, premature or small for gestational age (SGA) because postop the problems may be anticipated. (Ref 13)

The Beckwith-Wiedeman syndrome should be carefully considered in omphalocele patients. Remember that Beckwith’s syndrome can occur with small omphalocles. Down's syndrome (Trisomy 21) occurs with omphalocle as well as Trisomy 13 and 18.

Trisomy 13 infants have manifestations which may include a low birth weight, rockerbottom feet, microencephaly, convulsions, microophthalmia and colobomas, cleft palate and lip, profound mental retardation and an average life span of two to three months. 44% die within one month, 69% die at six months and 80% survive one year. The survivors have severe mental retardation, seizures and holoprosencephaly with decreased brain development. (Ref 15)

Trisomy 18 infants have low ears, flexion abnormalities of the first, second, fourth and fifth fingers which overlap the middle finger. They are low birth weight babies with congenital heart disease, gastrointestinal, genitourinary and CNS problems, (i.e., severe retardation). Cardiac defects may include atresia of the aorta, bicuspid aortic and pulmonary valves, pulmonary stenosis or coarctation. 30% die at one month, 80% die at two months and 10% survive for one year. (Ref 15)

It is also important to observe the umbilical cord of all newborns for a single umbilical artery. These patients have a 17% incidence of major associated congenital malformations. Only half of them have external evidence of malformation. (Ref 16)

The VACTER association, described by two Seattle pediatricians, includes a random series of malformations, and should be looked for. It may include vertebral anomalies, anal atresia, cardiac anomalies, T-E fistula, renal defects and radial limb dysplasia. (Ref 21,22,23)

A diaphragmatic hernia can occur with omphalocele. Therefore, during repair, the diaphragm should be palpated. Horseshoe kidneys may be present with omphalocele. One patient with omphalocele and macroglossia is known to have developed cor pulmonale from chronic airway obstruction secondary to enlarged tongue.

The omphalocele may be closed multiple ways: 1) by allowing the skin to grow over the amniotic membrane, 2) primarily closing the defect, or 3) by using a chimney type closure. (Ref 7,8,9) The gastroschisis must be closed primarily or a prosthetic chimney used.

The preoperative care of the neonate should include frequent monitoring of vital signs, warming of the baby, keeping a clean environment, cardiac monitoring and nasogastric tube; consideration of blood gases and/or echo-cardiogram if dictated by a chest x-ray and ECG. Intravenous fluids, anti-biotics, Vitamin K, blood sugar determination and blood gases may also be important.
POSTOPERATIVE CARE OF THE NEONATE

In the postoperative period, these babies should be placed in an intensive care unit. Frequent vital signs and strict monitoring of intake and output needs to be done. Daily weights are extremely important for assessing fluid balance and the adequacy of nutrition. Laboratory work should include electrolytes, bilirubin, blood glucose, BUN, creatinine and CBC. Intravenous lines will be needed and all but the simplest abdominal defect will benefit from an arterial line.

One very important feature of postoperative care can be an umbilical artery catheterization. These are extremely useful for blood pressure, blood sampling, blood access and for fluid administration. If the usual route through the cut end of the umbilical cord is not available, the subumbilical approach can be used. This can be cannulated for at least ten days after birth. The vessel is posterior to the rectus muscle and just anterior to the peritoneum. The length of the catheter to be placed can be determined by shoulder-umbilicus distance. (Ref 25) We prefer to place the line between T₆ and T₁₀. Major complications are approximately 2.5%. Therefore, this line should be used only with caution and in very ill neonates. Clot formation may be lethal. The tip of the tube has recently been implicated in thrombus formation. (Ref 24)

Gastrostomy in the neonate is usually performed with a Malecot catheter, #16–18 French. The Stamm technique is performed on the greater curvature of the stomach, bringing the tube out through a stab wound which is slightly smaller than the catheter. A marking suture of nylon is placed into the superficial substance of the tubing at the skin level so that if the tube slips inside the stomach it can be pulled back. The Foley catheter should not be used since it is very easily pulled into the pylorus and can obstruct the stomach. The tube is sutured to the skin for a few days to prevent dislodgement. The gastrostomy is connected to gravity drainage and irrigated with clear saline on a two hourly basis. The tube should be stabilized to avoid erosion of the skin.

When the stomach contents clear of bile, elevation of the tube is in order. Feedings are begun when bowel action resumes as evidenced by passage of stool or meconium. Gastrostomy in the neonate may be combined with a jejunal feeding catheter. Available commercial jejunal tubes include Keofed and Nutriflex. Hospital made tubes can be devised using radiopaque Silastic tubing as small as 1.08 mm internal diameter. The tip of the tube must be weighted. Feedings must consist of hypoosmolar solutions with Isomil or Pregestimil being satisfactory products. A gastrostomy in the neonate is extremely helpful because the newborn is a nose breather and swallowed air causes gastric distention. It can be used for long term feeding and prevents aspiration of gastric contents into the tracheobronchial tree. (Ref 27) Meticulous care can prevent known frequent complications. (Ref 28)

Hematologic problems frequently occur in the neonate. Blood loss may be crucial. It is well to remember that a 25% decline in circulating volume is reflected in a 50% blood pressure decrease in the neonate. (Ref 23) Transfusion of 1 ml/kg of packed red blood cells increases the hematocrit by approximately 1%. A specific formula for the amount of blood required to transfuse a patient to a desired level consists of multiplying the estimated blood volume (EBV) by the desired hematocrit (Hct) minus the product of EBV and actual hematocrit, divided by the hematocrit of the transfused blood:

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\text{ml blood} = \frac{(\text{EBV}) (\text{desired Hct}) - (\text{EBV}) (\text{actual Hct})}{\text{Transfusion Hct}}
\]

Remember that the newborn has an hematocrit of approximately 40–42%. This level drops to a low of approximately 30% at two to three months, becoming slightly higher after six months. Prematures will tolerate a hemoglobin of 6.5-7.0/100 ml. After blood transfusion, 50 mg of calcium should be given for each 100 ml of blood transfusion. (Ref 49)

Bleeding history in males on the maternal side may indicate hemophilia. Newborns all need Vitamin K, 1 mg, with prematures needing two to three times that amount.

If there is any manifestation of coagulation problems (Ref 31), laboratory workup should include partial thromboplastin time (PTT). The Pro-time (PT) must be done. The PTT is generally prolonged until nine months of age because of inadequate liver enzyme function. Thrombin time (TT) measures heparin effect. The platelet count should be done and anything less than 150,000 is abnormal. A count of less than 50,000 is worrisome and probably should be treated. Fibrinogen of less than 100 is abnormal. Bleeding in the presence of split fibrin products represents DIC.
If bleeding is present, fresh blood less than 12 hours old will give coagulation factors equal to that of fresh frozen plasma. Should the platelet count be low, a unit of platelets should be used for each 5 kg of body weight. Cryoprecipitate of 1 unit/kg increases the circulating Factor VIII by 20%. Factor VIII has a half-life of 8–12 hours. Cryoprecipitate contains 15–20 equivalents of Factor VIII compared to fresh frozen plasma. It also provides fibrinogen.

A transfusion reaction in the neonate is extremely rare. However, treatment should include adequate hydration combined with Mannitol 1 mg/kg, sodium bicarbonate 1 mEq/kg and hydrocortisone 1 mg/kg. Then, if the urine output is less than 2–3 ml/kg/hr, furosemide 1 mg/kg should be used.

Temperature control in the neonate is extremely important and it must be remembered that babies have poor tissue insulation with a large surface area to body mass ratio. The ideal skin temperature for a newborn is 36.2–36.5°C as this keeps oxygen consumption minimal in the full term baby. (Ref 33,34) The baby who is small for gestational age (SGA) needs a skin temperature of 36.5°C. The gradient between skin and rectal temperature should be less than 1.5°C to keep low metabolic activity. (Ref 35) The smaller the birth weight of the baby, the higher the incubator temperature; a 2 kg newborn requires temperatures somewhere between 34–35°C whereas a 3 kg baby needs an incubator temperature of 32–33°C. The temperature may then be decreased by .5°C each 12 hours times three. (Ref 36)

If cyanosis appears in the surgical neonate, chest x-ray, ECG, radial artery line, gases on room air with 10% O₂ and echocardiogram are all extremely helpful. The blood gas on 100% O₂, which changes little from room air, indicates cardiac shunting unless severe lung disease has already occurred. (Ref 37,38)

Sepsis in the neonate is an insidious problem which is often manifested by temperature instability, apnea, poor feeding or abdominal distension. Workup should include cultures of blood, urine, stool, wound, drainage and cerebrospinal fluid. In sepsis, the white blood count may be increased, but can be extremely variable. The platelet count below 100,000 is associated with an instance of a 70% chance of sepsis in a neonate. (Ref 39) If a newborn has an unexplained change in his condition, as noted above, think of sepsis and treat the patient with antibiotics until cultures confirm no evidence of infection.

Antibiotics should be used prophylactically in surgical neonates, starting preoperatively and continuing a short course of two days. Evidence of infection requires a full course of therapy. Usual doses of antibiotics in babies one to seven days of age are Ampicillin 25 mg/kg/12 hrs and Methicillin 25 mg/kg/12 hrs; in neonates 8–30 days of age, Ampicillin 25–50 mg/kg/8 hrs, Gentamycin 2.5 mg/kg/8 hrs and Methicillin 25 mg/kg/6–8 hrs. Remeber the dangers of antibiotics -- those of Gentamycin include renal damage and vestibular damage; Methicillin can cause nephritis. (Ref 39)

Seizures in the neonate may be of rather mild appearance. They frequently indicate other severe problems. Symptoms to be watched for include chewing movements, apnea, oculoc deviation, vasomotor changes and migratory jerking. The immediate laboratory workup should include blood sugar, calcium, magnesium, electrolytes, phosphate, protein and BUN. The clinical workup should include head circumference, funduscopic examination, transillumination of the skull, lumbar puncture, EEG, echogram of the skull and consideration of the CAT scan. Specific problems that must be considered include hypoglycemia, hypocalcemia, hyponatremia, meningitis, pyridoxine deficiency and amino aciduria. General care in the neonate with seizures includes maintenance of the airway and treatment with Phenobarbital 3–10 mg/kg I.V. over two to five minutes. One-half the dose may be repeated 30 minutes later with a maintenance dose of 3–5 mg/kg/day given 12 hours apart. Should the Phenobarbital fail to control seizures, Dilantin 5–10 mg/kg may be given slowly. Resistant seizures are then treated with paraldehyde 4% solution, 0.2 ml/kg/rectum or 10 ml of 4% solution placed in 250 ml of 2.5% dextrose with one-half normal saline. Then, 2.5–4.0 ml/kg are given over 10–15 minutes. (Ref 41)

Hypoglycemia can produce irreversible neurological damage and is frequently encountered in babies that are small for gestational age (SGA). (Ref 42,43) Symptoms of hypoglycemia include a jittery
baby, seizures, intermittent apnea, hypothermia and lethargy. Hypoglycemia is defined as a blood glucose level below 30 mg/100 ml during the first three days or 20 mg/100 ml in low birth weight infants. The risk is elevated after perinatal stress, including surgery. Our recommendation is that any patient with glucose less than 40 mg% should be treated. (Ref 44) Hypoglycemia may occur within four hours of birth, but usually between 24-72 hours of age. Thirty to 50% of neonates with seizures will have central nervous system damage. (Ref 45) The infant of a diabetic mother has a 50% chance of developing hypoglycemia. Birth hypoxia and maternal toxemia of pregnancy also increases the risk of hypoglycemia. (Ref 46) Frequent checks of the BG Chemstix should be carried out. Under 40 mg/100 ml the BG Chemstix are inaccurate. Treatment should be instituted and then a blood sugar checked.

Treatment includes dextrose 10%, 4-6 ml/kg I.V. stat with an I.V. of D10 D15 at 80 ml/kg/24 hrs for two days. If the patient is resistant to dextrose infusion, hydrocortisone 5 mg/kg/12 hrs may be given. The blood sugar level should be monitored every one to two hours on treatment. The Beckwith-Wiedeman syndrome produces hypoglycemia by causing hyperinsulinism. Hypocalcemia is also seen in surgical babies, especially in low birth weight (LBW) infants. The premature baby is especially at risk for hypocalcemia because 75% of calcium transport across the placenta occurs after the 28th week of gestation. (Ref 47) Term and small for gestational age (SGA) babies have a better placental transport of calcium. Premature babies also have a low parathormone level. (Ref 48)

Hypocalcemic symptoms include irritability, jitteriness, seizures and a high-pitched cry. The use of sodium bicarbonate and citrated blood decreases ionized calcium. Cow's milk contains low calcium and high phosphorus which increases the risk of hypocalcemia. Hypocalcemia is defined as a serum calcium less than 7.5 mg% or an ionized calcium of less than 4.4.

Treatment of hypocalcemia includes 1 ml of 10% calcium gluconate given I.V. over one minute. A full dose is 5 ml in a premature and 10 ml in a term baby. An ECG must be monitored for bradycardia or arrthymia during calcium infusion. The dose may be repeated in 15 minutes. Calcium maintenance should be 5-10 ml/kg/day of 10% calcium gluconate which gives 45-90 mEq/kg/day of elemental calcium. If hypocalcemia is not symptomatic, oral calcium is the best route of administration. Glubionate calcium (NeoCalglucon) contains 115 mg of calcium per 5 ml.

Hypomagnesemia is also associated with hypocalcemia. It is an index of fetal malnutrition and is often seen in babies small for gestational age (SGA). Normals are 1.4-1.7 mEq/L. Treatment includes 50% MgSO4, 0.1-0.2 ml/kg I.V. or I.M.; this can be repeated in 8-12 hours. While the drug is being given I.V., the physician should watch for heart block, hypotension or CNS depression. (Ref 50)

PARENTERAL NUTRITION IN THE NEONATE

Nutritional support is critically important in sick children. Parenteral nutrition saves more lives than any other recent development. (Ref 54) In addition to the short-gut syndrome and motility problems, hospitalized patients can easily develop viral gastroenteritis. Rotavirus and Norwalk-like virus may decimate the function of the G.I. tract. (Ref 51)

Guidelines for daily nutritional requirements in the neonate are: water 100-150 ml/kg, protein 2.5-4.0 gm/kg, calories 120-175 Kcal/kg, sodium 3-4 mEq/kg, potassium 2-3 mEq/kg, phosphate (PO4) 2-3 mEq/kg, calcium gluconate 0.5 mEq/kg and magnesium sulfate 0.25 mEq/kg. (Ref 53)

Laboratory monitoring of the neonate undergoing parenteral nutrition should consist of electrolytes and glucose every other day for the first week, daily weights, daily plasma turbidity, urine sugar, protein, acetone and specific gravity every six hours initially and strict intake and output. Weekly laboratory monitoring should include calcium, phosphate, BUN, magnesium, CBC, protein, bilirubin, alkaline phosphatase and SGOT. (Ref 52)

Trace elements are extremely important in the neonate. They include iodine, copper, zinc, chromium, manganese, cobalt, selenium, molybdenum, tin, silicon, nickel, zanadium and fluorine. (Ref 56) We use Vitamin K and folic acid as well as a mixture of Vitamins A, D, C, B1, B2, niacin, B6, E and biotin. (Ref 53) Vitamin B12 is given monthly. Blood of fresh frozen plasma is also recommended weekly.
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The caloric value of commonly used parenteral solutions is: 1) 0.58 Kcal/ml = amino acid 2.125% + dextrose 15% and 2) 0.75 Kcal/ml = amino acid 2.125% + dextrose 20%. Intralipid 10% contains 1.1 Kcal/ml.

Crystalline amino acids help prevent hyperammononemia. Patients need 150–200 nonprotein Kcal/gm of nitrogen. Protein should not be used as a calorie source. 2.125% glucose is the maximum that can be safely used in the neonate. The term infant tolerates dextrose 10% at 100 ml/kg/day whereas the premature infant must start with 5% dextrose and be carefully watched for intolerance. (Ref 54)

The fat emulsion, intralipid, should be used for less than 50% of the total calories. It is important because it provides essentially fatty acids including linoleic acid which is a precursor of other essential fatty acids. The lipid cannot be premixed with other solutions and we must use a 'Y' connector which joins the main line near its entrance to the parenteral nutrition catheter.

Lipids should be avoided in acute pancreatitis, lipoid nephrosis and pathologic hyperlipemia. The low birth weight infant has impaired clearance of triglycerides and free fatty acids. Also, free fatty acid displaces bilirubin from albumin and can be dangerous in the patient with hyperbilirubinemia. Patients with pulmonary hypertension and bronchopulmonary dysplasia should avoid intralipids because they collect pulmonary fat deposits more readily than other patients. Fat should be given slowly, at the rate of no more than 1.5 ml/kg/hr maximum and if the infusion falls behind it should not be increased.

Metabolic complications associated with total parenteral nutrition include hyperammononemia, metabolic acidosis, azotemia, postinfusion hypoglycemia, electrolyte deficiency, fat emulsion problems, coppr deficiency and hepatobiliary complications. Hepatobiliary complications primarily are those of intrahepatic cholestasis. (Ref 58) The theories as to why cholestasis occurs are basically three: 1) hepatotoxicity of amino acids, 2) fat deposition in the liver, and 3) enzyme induction in the liver due to the increased glucose load. (Ref 54)

RENAL FAILURE IN THE NEONATE

The ability of the newborn kidney to function is extremely limited and the specific gravity may be quite low, as much as 1.004. The urine volume may be low, in the range of 15–60 ml/24 hrs, with a creatinine clearance of 15–60 ml/min/1.73 M². The neonate with no urine production should have the bladder catheterized and the abdomen carefully palpated. If no kidney is felt, ultrasound will usually reveal the presence or absence of kidneys. Watch for pelvic kidneys. IVP is not reliable 24–48 hours after birth. The best diagnostic test for kidney presence is a renal scan using DMSA. Renal scans can be used to determine renal function and excretion.

Renal failure is defined as inadequate urine volume to maintain homeostasis of body fluids. A urine volume of less than 1 ml/kg/hr is suspect of renal failure. The laboratory diagnosis of renal failure depends on a urine sodium concentration of greater than 40 mEq/L, a urine to plasma urea ratio of less than five and a urine to plasma osmolality ratio of less than 1.15. These values are invalidated if diuretics are being used.

The treatment of renal failure in the newborn should first be a fluid challenge with approximately 10–20 ml/kg isotonic fluid and careful monitoring of central venous and/or blood pressure. If urine is not produced by that, furosemide 1 mg/kg is given. If there is no response, Mannitol 1 gm/kg is given if the patient is not volume overloaded. If no response, repeat the furosemide 10 mg/kg. Sometimes a Dopamine drip of 3–5 mcgm/kg/min will avert acute tubular necrosis.

The neonate in true renal failure should have a fluid limit of 300 ml/M², sodium of 0.3 mEq/kg/24 hrs and a low potassium diet with none given I.V. The fluid limit is changed to prevent hypo or hypernatremia.

Metabolic acidosis should be treated with sodium bicarbonate (NaHCO₃). The dose should be: mEq NaHCO₃ = body weight in kg x 0.3 x negative base excess; use one-half of the calculated dose.

Should hyperkalemia occur, the patient should have a continuous ECG monitor; 10% calcium gluconate should be given 0.5–1.0 ml/kg over two minutes. Subsequent treatment could include NaHCO₃ 1 mEq/kg which will decrease the K by 1 mEq/L, glucose 200–400 mg + insulin 0.1–0.2 units/kg and Kayexalate 1.0–1.5 gm/kg with 20% Sorbitol may be given per rectum. Kayexalate must be removed from the bowel before it becomes impacted.
Indications for dialysis are multiple. However, the most acute is hyperkalemia of greater than 7.0 mEq/L. Congestive heart failure with volume overload is another indication, as is uncontrollable hypertension. Seizures which are the result of uremia, as well as uremic pericarditis, also require dialysis. Other chemical results which urge dialysis is a BUN of 100–125 mg% and a creatinine in the neonate of 6–7 mg%.

The usual method of dialysis in a newborn is via the peritoneal route. (Ref 64) This requires insertion of a catheter under sterile conditions. Commercially available stiff temporary catheters can be used for four to eight days, but if dialysis is expected to last longer than ten days an implantable Silastic catheter with a Dacron cuff, such as the Tenckhoff catheter, should be implanted. The volume of solution infused should be approximately 100 ml. The volume used should not cause abdominal pain.

One cycle of peritoneal dialysis will require approximately one-half hour. The infusate for peritoneal dialysis is a commercial product. It is available as D1.5% or D4.25%. The solutions can be changed by adding sterile dextrose 50%. The solution contains NaCl 90 mEq/L, Na acetate 38 mEq/L, CaCl₂ 3.5 mEq/L, MgCl₂ 1.5 mEq/L, Citric acid 4.0 mEq/L and Na bisulfite 1.0 mEq/L. Potassium is usually not added to the dialysate unless the potassium is below 3.0 mEq/L or if the patient is on Digoxin, a serum potassium of 4.0 mEq/L is maintained. It is also important to culture the outflow on a daily basis in order to recognize early bacterial peritonitis.

A patient who has had a Silon pouch may have a relatively small peritoneal space for dialysis. Therefore, it is of note that hemodialysis in the neonate is routinely performed at the University of Minnesota. (Ref 54) The technique for hemodialysis of the neonate consists of cannulating the femoral artery and saphenous vein near its junction with the femoral vein. The flow rate necessary is approximately 20–30 ml blood/min. The tubing is kept as short as possible between the patient and the machine and the dialysis unit is primed with blood.

**RESPIRATORY CARE OF THE NEONATE**

Respiratory care in neonates may be the most complicated feature of all the aspects of care. (Ref. 66) Most abdominal defects closed primarily require ventilatory support.

It is well to remember that the normal blood pressure for a newborn is a systolic of 60–80 torr (Ref 76); a pulse of 120–160 beats/min may be normal and a PaO₂ of 60–80 torr. Signs of respiratory insufficiency in the neonate include tachypnea and tachycardia, rib retractions, apnea, grunting, exhalation and flaring of the nostrils.

Indications for ventilator support include cyanosis, apnea, increasing respiratory rate and exhaustion with rib retractions. In patients with abdominal wall defects, increased intraabdominal pressure limiting diaphragm motion is also an indication. Blood gas criteria for ventilatory support includes a PaO₂ of less than 60 torr (F₁O₂ 0.6–0.1) with a PaCO₂ of greater than 50 torr. A pH less than 7.30 due to respiratory acidosis is also important. A baby with IRDS would be allowed to have a PaCO₂ greater than 50.

We use the Bournes infant volume controlled ventilator, Model LS104–150, for surgical neonates. Ventilator characteristics of the Bournes which are important are: 1) its low inspiratory flow rate, 2) its rapid response to infant breathing, 3) delivery of a small and accurate tidal volume, 4) sensitive pressure limits, and 5) an adjustable rate for IMV. (Ref 67)

The Bournes ventilator has a volume which is readily adaptable to neonates, varying from 5–50 ml/breath with a rate of 1–80. The sensitivity which will trigger a respiratory cycle is a pressure change of 0.05 cm H₂O to 1.0 cm H₂O or a volume displacement of 0.05 ml H₂O. The ventilator also has a 35 millisecond response which is extremely rapid. It has a pressure limit setting and it can be used in the control, assist or intermittent mandatory ventilation (IMV) mode. Its principle disadvantage is that the only change between 10 and 20 is 15.

Initial ventilator settings include a tidal volume of 10–15 ml/kg, a respiratory rate of 20–25, a flow rate of 50–125, F₁O₂ of 1.0. The F₁O₂ is rapidly decreased to as low as acceptable blood gases are obtained. A positive end expiratory pressure (PEEP) setting of three to five is probably ideal. (Ref 70)

The objective of respiratory care is to ventilate until adequate spontaneous ventilation is
demonstrated in the patient. Prevention of respiratory exhaustion, undetected hypoxia, hypercarbia and acidosis are extremely important.

Management of the respirator patient includes a nasotracheal tube and $F_1O_2$ to maintain the $PaO_2$ 80–100 torr in an acyanotic patient. The tidal volume we prefer is 15 ml/kg. We try to maintain the $PaCO_2$ at approximately 35 torr and the PEEP at approximately 3 cm $H_2O$. Respiratory management in the neonate often requires control of respiration and if the patient breathes against the ventilator we use Morphine 0.1–0.2 mg/kg and Valium 0.1 mg/kg. If this does not adequately control the patient, we use Pancuronium 0.01 mg/kg as needed. (Ref 71) Once the patient is intubated and placed on the ventilator, we immediately get a chest x-ray, check for tube position and atelectasis and the blood gases are taken in 10–20 minutes. Should the blood gases deteriorate while the patient is on the ventilator, look for fluid overload, plugged endotracheal tube or pneumothorax. The diagnosis can sometimes be made with transillumination. Chest x-ray is important if there is time enough to obtain one. Chest tube placement is done lateral to the nipple in the anterior axillary line. In an emergency, a needle may be passed between the ribs. Pneumopericardium will cause an immediate decrease in blood pressure. Gastric distension must be watched for. Infection or atelectasis will often show deterioration in the blood gases. Mild fluid overload can decrease $PaO_2$ slightly.

Atelectasis is a common problem in the postoperative patient. Its management includes adequate oxygenation, chest percussion on a four to six hourly basis, irrigation and suction of the nasotracheal tube at least every two hours and selective expansion of the lung, (i.e., hyperinflation of the atelectatic segment on an hourly basis). PEEP is of great benefit. A PEEP of 10 is not unusual in the treatment of atelectasis or fluid overload of the lungs.

Bronchospasm is another problem in the patient with nasotracheal tube and ventilator care. Airway irritation from tubes and suctioning can cause bronchospasm. Fluid overload can be the culprit as can congestive heart failure. Treatment of bronchospasm includes hand ventilation, recemic epinephrine by nebulizer, diuresis, digitalization and chest x-ray.

One extremely serious problem can be infection with respiratory syncitial virus (RSV). RSV is potentially lethal in the postop neonates. It is a ubiquitous and highly contagious virus. It is present in northern climates, particularly during the months of January, February and March. Clinical characteristics in patients include cough, fever, tachypnea, wheezing and prolonged expiration. A chest x-ray will show hyperinflation of selected lobes with an interstitial infiltrate. Viral studies will confirm the diagnosis. A culture swab deep in the nares and throat is sent to the laboratory for indirect immunofluorescence. (Ref 73) There is no specific treatment for this disease. Respiratory support is important. Bronchodilators and steroids are ineffective. The best treatment is prevention by strict hand washing and keeping patients with RSV in isolation. RSV has a reported mortality of 25–65% in infants with congenital disorders. Its pathophysiology includes bronchiolitis, peribronchiolar infiltrate and edema, necrosis of the epithelium with mucous and debris obstructing the airway.

When weaning the patient from the ventilator, the hemodynamic state of the patient must be stable, the abdomen should be relatively soft and not distended, the $F_1O_2$ should be maximum of 0.35 and the PEEP no more than 3 cm $H_2O$ pressure. The IMV is then decreased at a rate of 1/hr to a rate of 2/hr. The patient is then extubated. Blood gases are taken with each change of the ventilator setting.

Extubation is performed in the a.m. The stomach is aspirated, the tracheobronchial tree is suctioned and 100% $O_2$ is given for one to two minutes prior to extubation. Also, one must be ready to immediately reintubate.

After extubation, the patient is kept NPO for at least four to six hours until there is evidence that the baby is swallowing adequately and is not having respiratory difficulties. A head hood with oxygen and mist is used. Chest percussion is used if atelectasis is present and the respiratory rate is carefully watched. Blood gases are repeated during the postextubation period. Decardon 1–2 mg may prevent laryngeal edema.

Reintubation is frequently required. In a recently studied series of our patients under three months of age who underwent cardiac surgery, the incidence of reintubation was more than 20%. It should be remembered that long term intubation may be carried out if the nasotracheal tube is relatively loose as it passes through the larynx. (Ref 66) Tracheostomy is seldom used.
The ventilator has high and low pressure alarms. When the high pressure alarm sounds, it is wise to check for kinking of the ventilator tubes. One must assure that the endotracheal tube is patent, that water has not accumulated in the ventilator tubes and the position of the endotracheal tube should be checked to be sure that it has not slid down one of the mainstem bronchi. If a sigh is dialed into the machine, the pressure limit must be high enough to allow for the additional volume. The most dangerous problem is mucous or blood clot obstructing the endotracheal tube. If irrigation with saline does not rapidly clear the tube, reintubation with a new tube should be performed stat. If one is absolutely certain that the airway is patent and that the ventilator is working properly, the patient may be sedated to control inappropriate respiratory effort. This will keep the patient from struggling against the ventilator and triggering the high pressure alarm.

The low pressure alarm may signify: 1) a leak around the endotracheal tube, 2) disconnected ventilator tubing, 3) ventilator failure, 4) improper setting, or 5) a low water level in the humidifier.

Care of the surgical neonate requires extreme dedication. Attention to abnormalities of multiple organ system is crucial. This paper attempts to consolidate details of pre and postoperative care needed by these babies.