Guest Editor

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Anesthesia for Pediatric Open Heart Surgery

Persons who participate in the care of pediatric patients tend to undershoot or overshoot in their general approach to small patients. Some consider pediatric patients simply as small people and by adjustment for body weight, expect adult type responses. Others are so impressed with differences between newborns and adults they treat all children as a separate animal species. Clearly infants and children are more nearly like humans than any other animal; it is equally clear that infants differ from adults in some highly relevant ways. Even though these differences tend to disappear as a child approaches 12 years, optimal care of the pediatric patient must recognize these differences, but not be overawed by them.

Compared to adults, infants have a greater surface area, metabolic rate and blood volume per unit weight. In a sense their circulation is hyperdynamic; they consume more oxygen, produce more heat which they can gain or lose more rapidly. At birth kidney function is not completely developed and infants have trouble regulating fluid and electrolyte balance in the fastididious fashion of adult kidneys. Infants are therefore easily overhydrated, dehydrated and in either case tend to retain sodium. Similarly liver function development is incomplete at birth and one cannot expect the hepatic metabolism of normal metabolites or of drugs to be as rapid or complete as in the adult. Most obvious is the lack of central nervous system development of the infant brain which may require two years.[1]

What do these differences imply with regard to pediatric anesthesia? First of all, any equipment used must be adjusted to pediatric size. The standard 5000 ml rebreathing bag on an anesthesia machine cannot be used for an infant whose tidal volume may only be 25 ml. Nor can a 1000 ml bag of intravenous fluid be administered to an infant whose total daily fluid requirement may be only 300 ml. Anesthesia breathing systems, endotracheal tubes, monitoring devices and drug solutions must be adapted to the small size. Second, special attention must be given to body temperature. Infants cool rapidly in the air conditioned operating room and heating blankets are inadequate to maintain body temperature. The special significance of hypothermia in infants relates to their mechanism for compensation. Adults shiver in response to cold, but infants do not. They possess a mechanism for increasing heat production which is similar to that of hibernating animals, a hormonal mechanism related to the presence of "brown fat". Shivering, a form of muscle exercise, may increase body oxygen uptake by 300%. Thus the cool baby rather then being protected from oxygen lack by a low body temperature may actually have a higher oxygen demand in the absence of shivering by virtue of his regulating mechanism. Finally there are differences in responses to anesthetic drugs. The immaturity of the infant central nervous system would lead one to expect greater sensitivity to general anesthetics. The converse is true. Higher concentrations of inhalation anesthetics are required to effect general anesthesia in infants than in adults. Paradoxically children are

generally more resistant to sedative and hypnotic effects of drugs than are adults. These observations seem inconsistent with the general belief that infants have decreased central nervous system irritibility. Yet reflexes which regulate breathing, the circulation and responses to hypoxia are clearly less well developed in the infant. In view of these facts, inhalation agents are generally preferred for pediatric anesthesia, primarily because their dose can be more precisely controlled. Both the intake and output of anesthetic agents can be controlled when the lungs are used as the route of drug administration. When intravenous drugs are used, very precise measurement of dose is required and in contrast to inhalation drugs once administered they cannot be retrieved.

These unique aspects of pediatric anesthesia are magnified in patients with congenital heart disease who undergo correction with cardiopulmonary bypass. Here superimposed are the special problems of an anatomically altered circulatory system, with intracardiac and extracardiac shunts flowing in either direction and at times with compensatory polycythemia, chronic metabolic acidosis and blood clotting defects. These patients present extraordinarily complicated hemodynamic problems which offer great challenges, both in understanding and treating the disease. For example, positive pressure ventilation with oxygen of severely cyanotic children with right to left intraventricular shunts might be expected to increase tissue oxygen. Actually arterial oxygen tension decreases because of the increased amount of cyanotic blood shunted to the aorta by positive pressure in the lungs.[3] Successful perfusion of such patients requires an appreciation of the higher oxygen demand, the greater unsaturation of venous blood, the benefits and hazards of hemodilution and the impact of all these on the balance between oxygen delivery by perfusion and the high tissue demand for oxygen.

The most remarkable aspect of these patients is their ability to tolerate well general anesthetics despite the gross anatomical distortion of their cardiovascular system. Indeed very high doses of inhalation anesthetics must be administered to patients with transposition of the great vessels because so little of their blood actually goes through the lungs to pick up the anesthetic.[2] A prime reason for this anesthetic tolerance is that in almost all instances congenital heart disease is associated with a healthy vigorous myocardium. This is in marked contrast to adult heart disease where rheumatic fever or atherosclerosis led to actual loss of myocardial tissue or subnormal function of tissue remaining. This is also the reason operations for correction of congenital heart disease are so gratifying. Once the anatomical defect is corrected the normal myocardium provides abundant tissue circulation, dramatic improvement with rapid recovery. For this identical reason, such gross distortions of homeostasis as deep hypothermia with hemodilution and circulatory arrest have been accomplished with reasonable success in the early treatment of congenital heart disease.

From these few examples, I believe it is obvious that in no aspect of anesthesia and surgery for pediatric open heart operations can these patients be considered just little people.

REFERENCES

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