



THE MAGIC SURGEON AND THE NICU

by John Salyer RRT-NPS, mbas, FAARC

A surgeon in the 1930's once famously remarked that surgery had reached its zenith and they had "learned everything" that was important to know about surgery. Fortunately, he turned out to be famously wrong. The progress made in the various fields of surgery has been nothing short of phenomenal. When I first started as a Navy Corpsman (just after the introduction of ether as an anesthetic), I worked the recovery room. Patients would come out after having a meniscectomy, with long scars on both sides of the knee and leg wrapped from groin to toe. They were kept in bed for days and could not attempt to walk for weeks. After my meniscectomy, I was walking the next day. Of course I couldn't slam

dunk after my surgery, but, well you know the gag.

Less than 100 years ago there was little a clinician could do to help babies born with congenital heart defects. Since then there have been enormous advances in their diagnosis and treatment.

No where, is progress in the surgical arts and sciences more evident than in the treatment of congenital cardiac defects.

There are now a wide variety of surgical and pharmacologic interventions for these defects, which have resulted in improvements in outcomes that might well seem magical to people from the beginning of the previous century.

I have personally experienced significant parts of this revolution. I can remember when certain attempted repairs often resulted in death in the O.R. or in the immediate post operative period. These events are now rare.

There are 35,000-40,000 infants born with significant congenital heart disease each year. Approximately 1/3 of these will undergo palliative or corrective surgery in their first year of life. These cardiac defects occur in about 10 of every 1000 live births. Approximately 4000 of these children with congenital cardiac defects will not reach their first birthday. It is estimated that 150,000 adults in the U.S. are now living with some form of complex congenital heart disease acquired in infancy. The Pediatric Cardiac Care Consortium is a benchmarking organization of 47 pediatric cardiac surgical centers. For the period 1997-2001 they reported cumulative pediatric cardiac mortality of 6.5%. This is much higher for some cardiac diseases and much lower for oth-

ers. By way of an example, survival rates for patients undergoing the Fontan procedure range from 98% in the immediate post operative period to 63%. This wide range is in part due to differences in the repairs used.

The average number of cases performed by centers conducting pediatric cardiac surgery is 106 cases per year. The conventional wisdom is that outcomes will be better in centers that do more cases, a truth that has been verified in a large number of adult types of procedures.

The most common form of congenital cardiac defects in children are ventricular septal defects, accounting for about 1/3 of all cases and occurring at a rate of 2-5 per 1000 live births.

Respiratory therapists play a very large role in the care of these patients. This ranges from pre-operative management techniques like pre & post ductal oxygen saturation monitoring, sub-ambient oxygen therapy, hypercarbic therapy, and post operative ventilator management.

Since many congenital cardiac defects involve mixing of oxygenated and de-oxygenated blood at the site of the ductus arteriosus, there can be considerable differences in oxygenation of arterial blood sampled pre-ductally versus post-ductally. This difference can be an important diagnostic tool. Sub-ambient oxygen therapy involves lowering the FIO₂ < 0.21 in order to assure increased pulmonary vascular resistance and help balance pulmonary and systemic blood flow in patients with single ventricle physiology. This is achieved by blending nitrogen with room air to lower the FIO₂ to 0.16-0.17. Hypercarbic therapy involves the inhalation of gas with approximately 3-4% CO₂ which also serves to increase pulmonary vascular resistance.

The post operative ventilator management of pediatric patients who have undergone surgical repair of congenital cardiac defects can be challenging. Management strategies vary widely depending on the type of defect and repair. I would encourage the interested reader to study: Salyer JW, Keenan J. *Congenital cardiac defects. In; Neonatal and Pediatric Respiratory Care. 2nd Edition. Editors: Cervinske M, Barnhart S. W.B. Saunders. 2003:512-538.* You should also keep an eye out for the next edition which will be available in early 2009: Salyer JW, Butui T, Crotwell D. *Congenital cardiac defects. In; Neonatal and Pediatric Respiratory Care, 3rd Edition. Editors: Cervinski M, Walsh B. W.B. Saunders. 2008: In Press.* Both of these chapters

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go into some detail about the various subtleties of the respiratory care and ventilator management different types of defects.

One of the most important things the RT can remember when caring for these patients is related to the pulmonary vascular resistance (PVR). It is beyond the scope of this column to examine all the affects of respiratory care interventions on PVR. But a simple rule of thumb is that changes in pH, oxygenation, and CO₂ can affect PVR and much of what the RT does in the post operative period is an attempt to help manage the balance between pulmonary and systemic blood flow using changes in PVR. Pulse oximetry is an important tool in managing these patients.

Tidal volumes are typically kept in the 6-8 mL/kg range, although occasionally they are increased to 10 ml/kg, depending on disease. As an example, in post-operative bi-directional Glenn repairs some people prefer to use larger tidal volumes and lower rates to allow for longer expiratory times, while keeping the same minute ventilation. The rationale is that pressures created within the thorax through the airways can be transmitted to the alveolar capillaries, causing a mechanical impediment to blood flow through the capillary bed with the resultant increase in PVR. Thus, keeping inspiratory time short and expiratory time long minimizes the effect of this pressure transmission.

I have watched the close-up video of our cardiac surgeons repairing a complex atrioventricular canal defect. They were essentially creating septa and valves that were not there at birth. It is a long and complex procedure. The entire surgical field was about 3 inches across. This is what I think Arthur C. Clark meant when he referred to, "sufficiently advanced technology".

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tion and outcomes more so than any dose above 20ppm. While ECMO is probably the best treatment for PPHN due to the fact that it bypasses the lungs completely, allowing for healing time, it is very expensive and imposes higher risk factors than other forms of treatment. iNO is the much preferred method of treatment and is easily used in conjunction with other forms of therapy such as high frequency and conventional ventilation. However, studies also show that while iNO does reduce the need for ECMO it does not prevent it. Many infants who were placed on iNO therapy still ended up requiring ECMO at some point in time, once their PPHN had become severe. An OI greater than 20 and an AaO gradient more than 600 after 4 hours of iNO therapy could be indicative of an immediate need for ECMO (Fakioglu, 2005). But research did find that infants placed on iNO when they were in a mild to moderate state of PPHN did not go on to require ECMO, only infants who were placed on iNO late, with severe PPHN failed the iNO treatment. It's been found that iNO improves oxygenation but doesn't reduce the incidence of ECMO/death when initiated at an OI of 15 to 25 compared to greater than 25. Studies are also looking at Magnesium Sulphate and Sildenafil for treatment. Sildenafil

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has been found to be a selective pulmonary vasodilator when given orally, intravenously or in an aerosolized form with no significant effects. Magnesium sulphate has also been shown to significantly improve oxygen index and alveolar-arterial oxygen gradient (A-aDO₂) within the first 24 hours. There have not been very many studies done on these two forms of therapy but certainly the outcomes warrant further investigation. It is proposed that if these really do work as well as they appear to they will be of great benefit to developing countries who cannot afford the more common treatments such as nitric oxide, mechanical/high frequency ventilation and ECMO.

There are many exciting results being found in the recent studies for Persistent Pulmonary Hypertension of the Newborn that project a kind of hope towards the future for better patient outcomes. With ongoing research of nitric oxide and extracorporeal membrane oxygenation it will be even better understood and possibly even improved upon. And with the positive research results done on Sildenafil and Magnesium Sulphate there is the possibility and anticipation that these drugs could be a turning point in care for patients in developing countries who have limited resources and money for treatment.