My Encounters with Neonatal Intensive Care

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Disclaimer. I did not need neonatal intensive care myself, and according to my parents and older siblings, was a vigorous ten-pound baby.
I grew up on a farm close to Ruakura in Hamilton.

Vets were frequent visitors as our farm was involved in breeding trials. I had to learn from the vet some of the proper names for his procedures.

I followed my older brother to medical school. Neither of us wanted to become farmers although that had been our father's own lifelong dream.

Ross Howie, my brother in law, later became famous along with Mont Liggins in their 1972 publication on the use of antenatal steroids. Some of his experimental work and observations on RDS in preterm lambs happened on our later farm that had sheep and cattle, not dairy cows.

A reminder of the challenges a newborn baby has, exposed to much brighter light, louder sounds, cold, gravity and the need to breathe air for the first time.

- To breathe air successfully
- Warmth
- Nutrition
- Infection control
- T.L.C from parent/ carer
- PKU test
- Well baby care

Some preterm and sick babies need extra care

- Close observation and monitoring
- Temperature support
- Enteral/ I.V feeding and metabolic support
- Extra oxygen/ respiratory support
- Extra infection control
- Jaundice treatment
- Attention to congenital malformations
- Treatment of birth injury, physical and birth asphyxia.
- Extra T.L.C from parents/ carers

Selected timeline of landmarks in neonatal care before my graduation.

1836 - birth registration mandatory in England

Some babies did not count for much and were not counted or named until they had survived for a time.

1848 - mandatory birth registration in NZ

1851 - (Marchant) first report of gavage feeding for infants

1857 - (Denuce) first published description of incubator in Western literature

1891 - (Bonnaire) first documented use of oxygen for premature or cyanotic infants

1893 - (Budin) pavilion of weaklings at Paris Maternité

1915 - first US birth registry

1934 - (Folling) discovery of PKU

1938 - (Chapple) modern incubator design (isolette)

1941 - (Clifford) RLF recognised

1942 - (Florey and Chain) first clinical use of penicillin

1948 - WHO defines premature as BW less than 2500 grams

1951 - (Kate Campbell) RLF linked to oxygen use

1952 - Virginia Apgar newborn scoring system

1956 - (Dobbs et al) sunlights bleaches bilirubin

1957 - introduction of thalidomide in Europe

1962 - (Paul Swyer et al) successful ventilation for RDS

1963 - introduction of Rhogam

1967 - I graduate from University of Otago

In Dunedin, Donald Malcom established neonatal care as a subspecialty in Dunedin in the 1950s. Patricia Buckfield (ex-Hammersmith) whose mentor was Pamela Davies, introduced ventilation and with it, neonatal intensive care in Dunedin in 1967, five years after Paul Swyer, one of my bosses in Toronto first described its successful use . The same year Jim Watt was appointed as the first professor of paediatrics in NZ in Dunedin

In 1970 when I was a paediatric registrar and allowed to start caring for neonates, there was some tension between our learning needs and the patient's needs. How many times should you attempt to insert a scalp-vein IV before handing over to someone more experienced? For how many seconds should you try to intubate a small baby before handing over or take over from the learner? In general paediatrics house surgeons are not supposed to carry out general procedures on children until they are proficient on adults.

Early ventilators were scarce. We had only one to start with. One bad night, we needed another, and the anaesthetist Mack Holmes kindly lost a lot of sleep successfully adapting a bird ventilator from adult to neonatal use. Later the "baby bird" was commercially available from overseas.

Monitoring of blood gases was needed from umbilical artery or capillary samples (one drop of blood) and fed into our blood-gas machine in the room next door. This needed to be calibrated twice a day and have its membranes changed every couple of days, and needed as much attention as the babies. We were happy some years later when a technician was available to do this.

Before the blood-gas machine, and on transports, the cyanotic threshold method (adjusting the oxygen level until the baby is only just pink rather than blue) was used to try to avoid RLF (retrolental fibroplasia now called called ROP- retinopathy of prematurity). Now, blood gases are measured non-invasively with skin electrodes and pulse oximetry.

There were four registrars to cover general paediatrics at Wakari hospital and Queen Mary hospital. We spent a lot of time travelling back and forth. Now there are 9.7 registrars all on the same site. I don't think that Dunedin's population has grown that much. The Queen Mary calls tended to be the most urgent. And for several years I lived in a flat above Wing-On, the green grocer on George street. There was a wooden fence at the back of the flat behind the pathology department morgue. I fixed a couple of boards so that I could take a shortcut when I needed to get to queen mary in a hurry.

Phototherapy

Although the action of light on bleaching the yellow stain of bilirubin was described in 1956 phototherapy was first described in 1970. An observant midwife had noted that babies cared for close to the windows in the postnatal ward became less jaundiced than the others. We decided to try phototherapy in Dunedin. We asked Norman Miller, who maintained all our equipment, to find some blue/white fluorescent lights and place them on top of an incubator with 2cm wooden spacers to avoid overheating and this makeshift system worked well. To start with, phototherapy was only used in NICU but later a new mother who was a medical colleague asked me why it couldn't happen in her room in the postnatal ward. I could not think of a reason why not, and so we set it up. Some of our nurses were unhappy about this at the time, I thought for territorial reasons. But now it is standard practice for babies who are healthy otherwise. A few years later we did a study of jaundice in full term healthy babies. One of the factors we recorded was how close to the windows that mother and baby were. We found no effect, and concluded in our publication that phototherapy would not have been discovered in Dunedin.

Before phototherapy exchange transfusion was the only treatment for severe jaundice. When I first started as a registrar we were doing around 200 of these each year. The procedure took about 2 hours and needed full surgical technique. It was a bit boring but the benefit was that no one could ask you to do anything else while you were "scrubbed up", except give advice. Now exchange transfusions are uncommon to rare. There

are several reasons for this. One was Vigintiphobia (fear of the number 20, which is the bilirubin level which if exceeded could lead to lawsuits especially in the USA). Also the introduction of Rhogam in 1963 obtained from rhesus negative prisoner volunteers to prevent Rhesus disease, a form of haemolytic anaemia in the fetus. Also in 1963 Bill Liley pioneered intrauterine transfusions for the same condition.

An oxygen rich atmosphere is a dangerous fire risk. We had a registrar from Ghana, which is mostly flat. He had been in NZ for a few days when I met him at Momona. I used to like showing visitors or new arrivals the view of Dunedin from Signal hill. And on the way up I could see that James was becoming distressed. I asked him what was wrong and he told me that he was afraid of heights. I asked him how he managed on the plane, and he said “I closed my eyes”. Soon after he was in NICU and in the process of trying to give up smoking was sucking on one of those white sweets that had a red tip and looked like a cigarette. Patricia Buckfield, our boss, glanced in the window to where James and I were assessing a baby and thought that he was smoking. She hurried through the door shouting and took a while to calm down and kind of apologised when it was explained.

While I am remembering Patricia Buckfield, a comment about brain imaging. We were puzzled about a baby with poor temperature control that suggested a possible brain problem. The baby’s head shape and head x-ray looked normal but did not show the soft tissues. We thought we would use transillumination and took the well wrapped baby to the only nearby place with a blackout which was a small linen cupboard on the post -natal ward. One of us held the baby and the other the torch while we waited to get dark adapted. There was not much room in the cupboard. The door was suddenly opened by a nurse aid who was getting sheets. What a surprise she had. The baby had hydranencephaly and their head lit up “like a chinese lantern” as described in this condition. On study leave in Toronto, about ten years later, I saw my first CT scan of heads.

Patricia Buckfield and generations of us registrars collected perinatal information and examined around 20,000 babies born at QM as a part of

her MD thesis. One year-cohort of this group was used for the famous Dunedin child development study which is now in its 50th year.

Transport
Dunedin was the base hospital for Otago and sometimes babies from all over were born needing extra help. Of course if this could be predicted, it was best if the mother and baby were transferred antenatally. If not, at any hour a registrar would set off to Oamaru, Alexandra, Redroofs or elsewhere, in an ambulance with our porto-cot and minimal monitoring gear. Once our hospital engineers made a sturdy base for the cot on wheels with drawers to hold supplies. I used it once and thought it was too heavy for the ambulance driver and me to lift in and out of the ambulance. So without a baby in it, but with the oxygen bottle in place, I later wheeled it across the roads to the pathology department scales where it weighed in at 90 kgs. It mostly sat in the corner of the equipment room after that. When a new porter arrived the old one went straight to our museum.

Ethical dilemma: I once volunteered to take a baby with a heart problem to Auckland. The baby needed urgent surgery at Greenlane hospital and was very ill. Back then we went on a commercial flight and took up three seats at the front of the plane. The flight attendants were always attentive and helpful. My dilemma was that as well as transporting the baby I hoped to attend the annual paediatric conference starting in Auckland the next day The plane had a stop over in Wellington. What if the baby died before we got there? Would I have to tell people and leave the plane with the baby in Wellington? If the baby died, would anyone actually notice? There were no beeping monitors available to flatline. I was most relieved when I handed the baby over alive to the Auckland transport team at Auckland airport.

In Toronto, the Hospital for Sick Children was connected to nearby obstetric hospitals by a system of tunnels up to 1 km long. We would wheel a transport incubator underground beneath sun, rain, or certainly snow, through CCTV controlled checkpoints as the territory of one hospital changed to the next. You would press the buzzer and wait for

the security person to wake up and decide that you looked “legit” and unlock the door.

HSC Toronto for a registrar/ resident was like working in a living medical museum. It was a quaternary hospital accepting referrals from all over eastern Canada and north eastern USA, for some conditions. My first rotation there was to Sioux lookout in northern Ontario where the base hospital served the Cree Indian people on reservations. Their conditions were not good. The next rotation in Toronto in the emergency department made me learn quickly with helpful advice from nurses about how to cope with suspected snake bites, and rabid squirrel or dog bites. Seven G, the neonatal wards averaged 15 to 20 ventilator babies all the time. We did 24 hour shifts. This placed me well for a neonatal fellows position at McMaster university in Hamilton Ontario the following year. Living close to Niagara falls means that you show them to visitors in all seasons. One visitor, Jim Watt, who was my role model in paediatrics and the first paediatrics professor in NZ, visited and asked if I would like to return to Dunedin to continue from Donald Malcolm, who was retiring, as a neonatologist. I said yes.

Dunedin

I worked with neonates for around 20 years. For 5 of those years, Patricia Buckfield and I were on call alternate days, nights, and weekends, so evenings off included a lot of catch up sleep. We used to complain that obstetricians would deliver high risk babies just before bedtime and hand them over to us with a sense of “mission accomplished.” For us the night was just starting.

In large centres senior medical staff on call at night rarely have to get out of bed for work because there is a hierarchy of residents and Fellows who can cope with most things. In Dunedin the front line person was a registrar who often had not looked after neonates before.

The ethics of the lengths we went to to try to keep some clearly damaged babies alive concerned me. So after a period of study leave in London I returned to concentrate on developmental and behavioural issues in children, many of whom had received Neonatal Intensive Care.

At the time I moved away from NNIC (neonatal intensive care), the smallest babies that had a reasonable chance of intact survival were around 1000 grams (around 28 weeks gestation). Since the use of surfactant and other improvements in NNIC the lower weight limit has become lower still.
Jon Tyson was a neonatal Fellow with me at McMaster. He has worked in a large NICU in Dallas all his career as a consultant and led a large multicentre trial.

How small is too small? Jon Tyson et al 2008 (NEJM)

- This study involved 4446 babies aged 22-25/ 40 weeks gestation
- 80% had IPPV
- 49% died
- 61% died or had profound impairment
- 73% died or had profound or some impairment
- Follow up at 2 years (too early to show more subtle problems such as ADHD or learning problems on starting school)

Survival (%)

22 weeks	23 weeks	24 weeks
5%	20%	30%

Survival without profound impairment (%)

22 weeks	23 weeks	24 weeks
2%	12%	25%

(Definition of impairment)

Profound impairment - untestable on Bayley scales or gross motor function score 5

Some impairment - Bayley scale less than 50/ 150

- Moderate to severe cerebral palsy
- Bilateral blindness
- Bilateral hearing loss, needing hearing aids

Cost per survivor without profound impairment

Days in hospital per survivor without profound impairment

22 weeks	23 weeks	24 weeks	25 weeks
300	250	175	140

Cost per survivor 5.000 USD (2023) per day

1,500,000	1,250,000	850,000	700,000

* Cost to discharge from hospital does not include cost of non-survivors or profoundly impaired or follow up needs.

This leads to some complex ethical issues of resource allocation. At what gestational age or birthweight is it just too hard to determine. The usual wisdom is that half of the health budget is spent on people within two years of their death. Should it be spent at an earlier age when the prospect of adding many more quality-life-years exists? In paediatrics the answer to that question is usually easy but perhaps not quite so easy in this situation.
Sorry, I have no answers for you today.

Thank you.