The use of neonatal bubble Continuous Positive Airway Pressure in a rural hospital setting

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ABSTRACT

AIM: This retrospective review examined the introduction of bubble Continuous Positive Airway Pressure (bCPAP) in resuscitating neonates in a rural hospital environment.

METHODS: A retrospective audit of all emergent neonatal presentations to a rural emergency department (ED) over a 5-year period prior to (pre) and a 3.5-year period following the introduction of bCPAP (post).

RESULTS: Sixty-seven neonatal resuscitations (31 pre- and 36 post-introduction of bCPAP) were reviewed, having an average gestation of 37.4 weeks and birth weight of 3,110g, with no significant difference in characteristics between groups. Time in the ED was significantly longer post-bCPAP (202±93 vs 156±70 mins), but time applying T-piece assisted ventilation was significantly reduced (55±40 vs 94 ± 84 mins). There was an 11% reduction in the use of aeromedical retrieval and an 18% reduction in admissions to the regional level III neonatal intensive care unit (NICU) with a corresponding increase in admissions to local level II NICU.

CONCLUSION: The introduction of bCPAP into a rural hospital setting is technically feasible and results in less time spent on technically demanding hand ventilation, fewer admissions to level III neonatal intensive care units and a reduction in the use of aeromedical retrieval assets.

In Western healthcare settings, 3–8% of all births will require some form of neonatal resuscitation with respiratory support.[1] In Australasia, 2.9–3.7% of all live births will be admitted to a level III neonatal intensive care unit (NICU), with over 90% of these admissions for ongoing respiratory support.[2] Initial neonatal resuscitation algorithms emphasise the application of positive airway pressure in situations of respiratory distress, hypoxia and bradycardia.[3] This is commonly applied via a facemask and T-piece arrangement for the initial resuscitation (e.g., Neopuff™) with a transition to non-invasive ventilatory (NIV) equipment, or intubation and ventilation for ongoing respiratory distress.

The use of NIV modes of support is usually confined to dedicated neonatal units, reflecting the higher intensity of nursing care required. The use of NIV outside of these settings is limited and largely confined to specialised neonatal retrieval teams. In rural settings, neonates requiring retrieval can experience prolonged waits for the arrival of specialised retrieval teams. Timeframes of many hours would not be unusual, and it leaves little choice for rural medical teams but to continue to provide prolonged pressure support with a T-piece device. The effective and consistent application of T-piece pressure support can be technically challenging to the occasional practitioner.[4] Furthermore, in rural hospitals with limited staffing, the delivery of ongoing facemask pressure support can be a significant drain on resources and may lead to delay in further care interventions.

Bubble Continuous Positive Airway Pressure (bCPAP) provides continuous positive pressure that improves lung functional residual capacity, oxygenation and work of breathing.[5] There has been a trend towards an increased use of bCPAP and other non-invasive modalities in preference to intubation- and ventilator-driven positive pressure ventilation.[2] Bubble CPAP does not require a ventilator, is relatively inexpensive and is simple to use. Within emergency departments (EDs) the increasing use of adult and paediatric NIV (i.e., nasal humidified high flow cannula [HFNC], CPAP and Bilevel Positive Airway Pressure [Bi-PAP]) has improved both the expertise and comfort of staff with equipment and concepts common to neonatal bCPAP delivery.

In this study we describe the introduction of bCPAP via a protocol (Appendix) incorporating a step down to HFNC for ongoing respiratory support to neonates in a rural New Zealand hospital prior to transfer to higher care facilities. Taupō Hospital

has a primary midwife-led birthing unit delivering approximately 170 planned low-risk births per year. There is no onsite paediatric or obstetric support, with the nearest such service 85km away at Rotorua (including a level II NICU) and tertiary neonatal support services 150km away at Hamilton (level III NICU). The immediate response to neonatal emergencies is via a co-located ED staffed with rural hospital medicine specialists and/or emergency physicians. The introduction of bCPAP and a protocol to determine ongoing respiratory support, mode of transfer and receiving destination was an attempt to improve pre-retrieval neonatal care. The development of management and retrieval protocols with the ability to de-escalate interventions may provide flexibility in retrieval options, important in saving system resources and unnecessary transfers.

Methods

A retrospective chart audit was conducted based upon a search of records for all attendances for those aged 2 days and under at the Taupō Hospital Emergency Department from January 2014 until July 2022. All medical records, including electronic and paper, were individually interrogated for demographic, intervention and outcome data. Supplemental review of electronic records from other facilities were reviewed when available.

Presentations not requiring any form of resuscitative intervention were removed from the audit. The remaining patients were divided into two groups; those that were seen prior to January 2019 and those after. This corresponds to the time point at which bCPAP became an operational possibility in our department.

Pearson's 2-tailed t-Test was performed to determine any significant differences with $p<0.05$. This study was granted ethics approval by the Te Whatu Ora Lakes Research and Ethics Committee.

Results

There were 67 neonatal resuscitations over the study period. Demographics of the entire cohort and the pre- and post-bCPAP groups are shown in Table 1. All but one baby was born in the Taupō Birth Suite.

During the pre-bCPAP era, there were eight transfers that utilised respiratory support, all via

Table 1: Demographic data of total group and pre- and post-bCPAP introduction.

	Total	**Pre**	**Post**
Neonates	**67**	**31**	**36**
Gestation, weeks (SD)	37.4 (3.7)	37.7 (3.5)	37.2 (3.9)
Birthweight, grams (SD)	3,110 (856)	3,139 (833)	3,085 (887)
Apgar, 5 minutes (SD)	8.3(1.8)	8.3 (1.8)	8.2 (1.8)
Temperature on arrival ED (°C)	36.3 (1.0)	36.2 (1.2)	36.5 (0.8)
Term (37+) (%)	**48 (71.6)**	**22 (71)**	**26 (72.2)**
Moderate pre-term (32–36+6) (%)	13 (19.4)	8 (25.0)	5 (13.9)
Very preterm (28–31+6) (%)	4 (6.0)	0	4 (11.1)
Extreme (<28) (%)	2 (3.0)	1 (3.2)	1 (2.8)
D/C diagnosis*			
TTN	34	15	19
RDS	10	10	7
Mec asp	6	2	4
Other	17	11	6

*Diagnosis on electronic discharge from admitting hospital.
TTN = transient tachypnea of the newborn; RDS = respiratory distress syndrome; Mec asp = meconium aspiration.

helicopter, including four intubations, one on HFNC and three on bCPAP. Of the road transfers, 12 received no documented respiratory support during transfer and seven received low-flow oxygen via nasal prongs. In contrast, during the bCPAP era 27 of the 32 patients received respiratory support during the retrieval; 19 transferred on HFNC and nine on bCPAP, with one intubated and five with no respiratory support in place.

Discussion

This retrospective audit demonstrates an 11% reduction in the use of the regional helicopter retrieval service, with an accompanying 18% reduction in admissions to a level III NICU for babies older than 32+0 weeks following the introduction of bCPAP and HFNC into a rural hospital. Furthermore, the ability to provide bCPAP results in a 40% reduction in the time spent applying T-piece respiratory support. Although the protocol resulted in a significantly longer 40-minute length of stay, fewer babies required a higher level of care and 6% were able to avoid transfer to a NICU altogether.

Current practice in New Zealand dictates all babies under 32 weeks gestation be admitted to a level III facility for ongoing care. Babies older than

Table 2: Time in ED total and by mode of retrieval, time on Neopuff.

	Pre	Post
Neonates	**31**	**36**
Time in ED, minutes (SD)	156 (70)	202 (93)*
Time in ED helicopter	209 (76)	252 (111)
Time in ED ambulance	133 (54)	179 (75)
Time on Neopuff, minutes #	94 (84)	55 (40)*
Time on bCPAP (SD)	n/a	131 (109)

#Neopuff duration less than 10 minutess not included in analysis.
*Significant difference (p≤0.05).

Table 3: Numbers of neonates by destination and retrieval mode, pre- and post-bCPAP introduction.

	Pre	Post
Admission destination		
<32week Level III Waikato	1	4
≥32week Level III Waikato	8 (27%)	3 (9%)
≥32week Level II Rotorua	22 (73%)	27 (84%)
d/c	0	2 (6%)
Retrieval mode (≥32 weeks)		
Helicopter	8 (27%)	6 (19%)
Road ambulance	22 (73%)	24 (75%)
d/c		2 (6%)

d/c = discharged home.

32+0 weeks may be admitted to a level II facility. In our region, due to equipment constraints, current practice is to aeromedically retrieve all babies—irrespective of gestational age—who are receiving bCPAP. A majority of these will be transferred to the level III facility, likely because this is logistically easier for the retrieval team. Our protocol allows for the potential step down onto HFNC following a period of bCPAP if improvement is seen in neonates older than 36 weeks. This necessarily prolongs their stay in the ED but allows for transfer by road ambulance using an incubator (Dräger Isolette TI500) and local nurses as escorts rather than using a dedicated regional aeromedical neonatal retrieval team. The ability to step down to HFNC did reduce the number of both aeromedical and level III NICU retrievals, and thereby reduces the burden on specialised regional retrieval assets as well as keeping patients and families closer to their homes.

The resuscitation of a neonate is resource intensive and requires continual input from at least one senior doctor and at least one nurse. This may well be the entirety or majority of departmental staff in a rural hospital. The need to provide ongoing respiratory support via T-piece is technically demanding and essentially locks the practitioner into ongoing airway management exclusively. The introduction of bCPAP reduced T-piece ventilation from 94 to 55 mins on average; this would have a dramatic impact on resource management within a rural department, freeing staff for other interventions and often for the care of other patients.

There is an increasing familiarity with non-invasive ventilation technologies in EDs, such that the application of CPAP, BiPAP and HFNC to both adults and children is usually familiar to most emergency practitioners. The extension of these technologies to neonates within such departments should be technically feasible. In our experience, a crucial element of introducing bCPAP is the ongoing technical, logistical and moral support from appropriate colleagues within the receiving facilities. Our protocol governing the use of both bCPAP and HFNC for neonates has undergone iterative refinement with regular feedback and case review from paediatricians and neonatologists. Each case is managed with real-time telehealth or phone guidance and oversight by on-call neonatologists/paediatricians at the receiving facility. While not a specific focus of the retrospective review, there were no cases of iatrogenic harm or complications arising from the application of bCPAP in our department.

In summary, there are technical and logistical benefits to the introduction of bCPAP into rural facilities. Although not directly measured, there are likely to be physiological benefits in applying best practice interventions earlier in the treatment of neonatal respiratory distress. We have shown that rurality and lack of onsite specialist neonatal services should not be seen as a barrier to implementing appropriate care. Rural EDs are already dealing with neonatal resuscitations and have familiarity with many modalities of non-invasive ventilation already. With appropriate tertiary support the introduction of bCPAP into rural hospitals is feasible and in line with best practice treatment of neonatal distress.

COMPETING INTERESTS
Nil.

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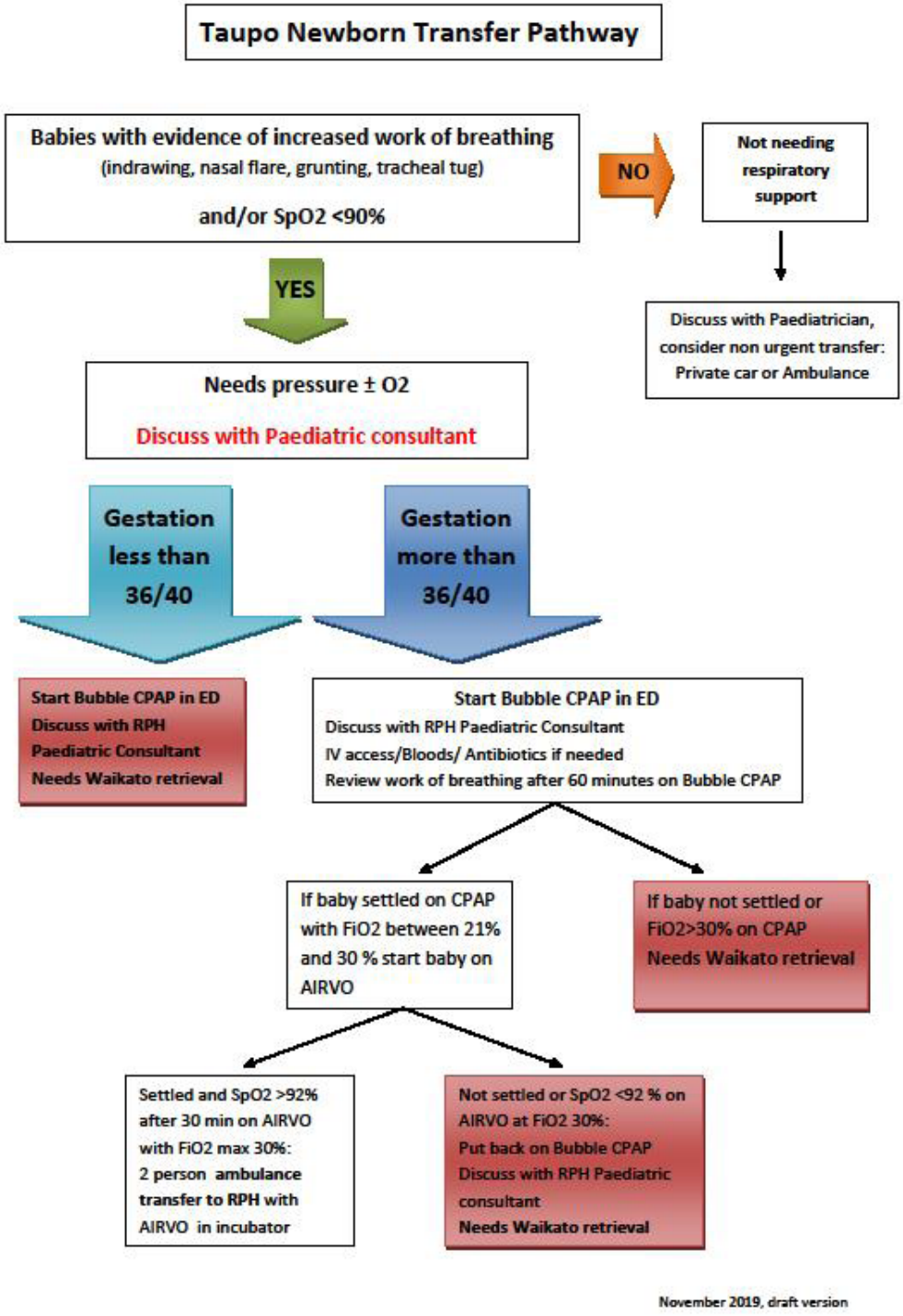
Appendix


Taupo Newborn Transfer Pathway
Babies with evidence of increased work of breathing
(indrawing, nasal flare, grunting, tracheal tug)
and/or SpO2 <90%
NO
Not needing respiratory support
Discuss with Paediatrician, consider non urgent transfer: Private car or Ambulance
YES
Needs pressure ± O2
Discuss with Paediatric consultant
Gestation less than 36/40
Gestation more than 36/40
Start Bubble CPAP in ED
Discuss with RPH Paediatric Consultant
Needs Waikato retrieval
Start Bubble CPAP in ED
Discuss with RPH Paediatric Consultant
IV access/Bloods/ Antibiotics if needed
Review work of breathing after 60 minutes on Bubble CPAP
If baby settled on CPAP with FiO2 between 21% and 30 % start baby on AIRVO
If baby not settled or FiO2>30% on CPAP
Needs Waikato retrieval
Settled and SpO2 >92% after 30 min on AIRVO with FiO2 max 30%:
2 person ambulance transfer to RPH with AIRVO in incubator
Not settled or SpO2 <92 % on AIRVO at FiO2 30%:
Put back on Bubble CPAP
Discuss with RPH Paediatric consultant
Needs Waikato retrieval
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