REVIEW ARTICLE

Feasibility of bubble continuous positive airway pressure in secondary facilities in low and middle income countries

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Abstract

Background: Newborn respiratory distress is a leading cause of neonatal morbidity and mortality in developing countries. While there have been considerable reductions in child mortality in low and middle income countries (LMIC) in recent years, reductions in neonatal mortality have not been as substantial. Bubble CPAP (bCPAP), mechanical CPAP, and mechanical ventilation are all used to treat respiratory distress syndrome and other pulmonary complications in newborns.

Methods: This study reviews the evidence for the efficacy, safety, and feasibility of bCPAP in neonates with respiratory distress in secondary facilities in LMIC. A systematic search (January 2014–January 2018) was performed of MEDLINE (PubMed), Cochrane, Embase, CINAHL, and Google Scholar. Articles reporting on bCPAP for respiratory distress in infants <28 days of age in hospitals in LMIC were included in the qualitative synthesis.

Results: Three studies reported on bCPAP in secondary hospitals. The majority of infants given bCPAP survived to discharge. The most commonly reported complication of bCPAP was nasal irritation. CPAP and bCPAP use is increasing in LMIC, but appears limited to urban tertiary care centers. There is a paucity of information in the medical literature regarding bCPAP use in secondary settings.

Conclusion: There is evidence that bCPAP, when used in tertiary care settings in LMIC is feasible, safe, effective, reduces the need for mechanical ventilation and ventilator CPAP, and may improve survival. There is very limited evidence supporting the feasibility of bCPAP use in secondary facilities in LMIC.

Key words: bub CPAP, respiratory distress, tertiary setting, low and middle income countries

1. Introduction

Newborn respiratory distress, a leading cause of neonatal morbidity and mortality, can result from premature birth, intrapartum events, birth asphyxia, neonatal pneumonia, and respiratory distress syndrome (RDS).[1] While there have been considerable reductions in child mortality in low and middle income countries (LMIC) in recent years, reductions in neonatal mortality have not been as substantial. In these countries, neonatal mortality has been resistant to interventions, with survival gains much less dramatic than child survival improvements.[2]

Bubble CPAP (bCPAP), mechanical CPAP, and mechanical ventilation are all used to treat respiratory distress syndrome, and other pulmonary complications, in newborns. In the last decade, CPAP utilization has increased dramatically in high income countries due to extensive evidence for its use as an alternative to mechanical ventilation, in properly selected patient populations.[3] In the U.S., CPAP utilization has increased among Level 1, 2, and 3 nurseries.[4]

CPAP (both bubble and mechanical) is increasingly used as an intervention to treat respiratory compromise (RDS, pneumonia, hyaline membrane disease, transient tachypnea of the newborn, and other conditions) in LMIC.[5,6] Even though CPAP use is increasing in LMIC, reports in the medical literature frequently originate from large urban medical centers or teaching institutions with NICU facilities and staff.[5,7,8,9]

For widespread use in secondary facilities, mechanical ventilators may be too expensive and too complicated.[1] Conversely, bubble CPAP has been shown to safely reduce the need for mechanical ventilation in tertiary hospitals, to be a superior alternative to ventilator CPAP, and may improve survival in these settings.[1,7,10,11,12,13,14,15] Bubble CPAP is simpler to use and is more cost effective, both in terms of direct costs (e.g., equipment, supplies, and lab) and indirect costs (e.g., hospital stay).[16,17,18] The feasibility of implementing bCPAP by nursing staff has also been demonstrated in LMIC, with appropriate training and retraining.[16,19] This intervention is thus very attractive in LMIC secondary facility settings, and preferable to mechanical ventilation and ventilator CPAP in appropriate patients.[20,21]

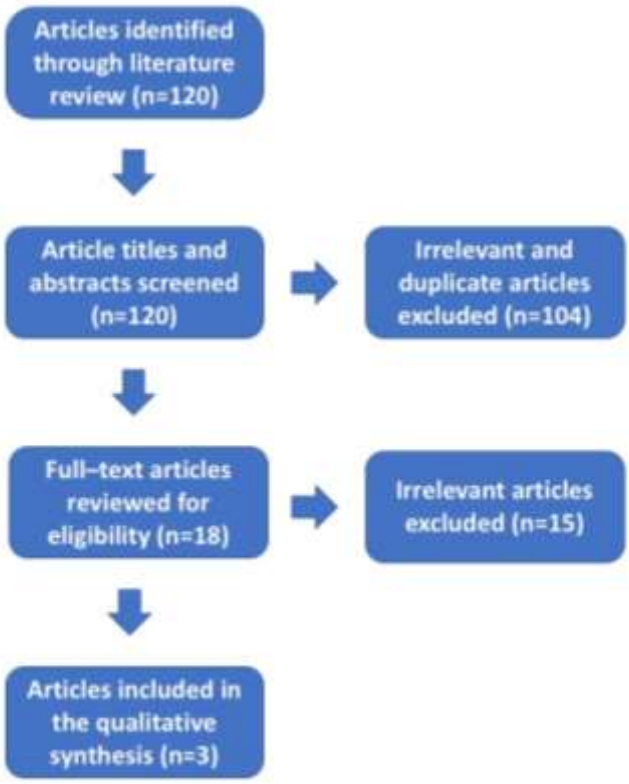
BCPAP implementation in secondary facility settings should be informed by research and guidelines emanating from secondary facilities.[11]This study reviews the evidence for the efficacy, safety, and feasibility of bCPAP in neonates with respiratory distress in secondary facilities in LMIC.

2. Methods

A systematic search (January 2014–January 2018) was performed of MEDLINE (PubMed), Cochrane, Embase, CINAHL, and Google Scholar using search terms described in a systematic review by Thukral et al.[21] These search terms include "'continuous distending pressure', 'CPAP', 'CDAP', 'distending pressure', 'continuous positive transpulmonary pressure', 'continuous transpulmonary pressure', 'continuous inflating pressure', 'positive pressure', 'positive expiratory pressure', 'positive end expiratory pressure', 'PEEP', AND LMIC."[21] In addition, the following search terms were used: 'bubble continuous positive airway pressure,' 'bubble CPAP,' 'bCPAP,' 'neonatal', 'newborn', 'low income country', 'middle income country', developing country', 'southern country.'

Figure 1 depicts the selection of articles in the review. Articles meeting inclusion criteria (bCPAP for respiratory distress in infants <28 days of age in hospitals in LMIC) were assessed. Outcomes included need for mechanical ventilation, complications, and mortality. Process measures included hospital setting, device acquisition and management, implementation training, and protocols for utilization. Articles that were irrelevant or duplicates were excluded from the review. The systematic search did not include articles prior to 2014, as these were reported in earlier literature reviews.

Figure 1. Flow chart depicting the selection of articles



Using the SORT strength-of-recommendation taxonomy,[22] the articles were Level 2 (limited-quality patient-oriented evidence), and Level 3 (other evidence) studies. No high quality (Level 1) evidence, such as randomized controlled trials or prospective cohort studies were found in the literature.

3. Results

Only three studies reported on bCPAP in secondary hospitals.[14,20,24] In Rwanda, a retrospective cohort study of preterm and very low birth weight infants at three rural hospitals was conducted. The results of the study revealed that 18 out of 43 (or 41.8%) of those placed on bCPAP survived. While no complications to therapy were found, providers had significant difficulty with correctly identifying newborns eligible for bCPAP.[20]

In Uganda, a case series study of neonates admitted to a district hospital was conducted. Of the 21 neonates treated with bCPAP, 11 (52%) survived to discharge. Complications of bCPAP therapy included nasal irritation in 14% of neonates.[14]

A second study in Rwanda reported on the results of a neonatal training program implemented at two district hospitals and two university hospitals. The program focused on various components, including nutrition, thermoregulation, record keeping, and bCPAP, While bCPAP was administered to 365 infants, survival rates were not reported. Tissue damage (to the nose and face) was reported in 13% of cases. No significant technical problems were observed. Overall neonatal mortality at the district hospitals decreased from 10% to 8.1%.[23]

Another study reported on a simple algorithm for appropriate initiation of bCPAP, called the TRY CPAP algorithm.[24] The algorithm was validated in a tertiary facility for use in the district (secondary) hospitals of Malawi.

Table 1. Summary of Key Articles

Author, Year	Country	Study Design	Study Population	CPAP Strategy	Results
Nahimana, 2015[20]	Rwanda	Retrospective cohort study	135 preterm/very low birth weight (PT/VLBW) infants admitted to three secondary hospitals between February and October 2013.	A total of 83 (61.5%) infants were eligible for bCPAP. Of the eligible infants, 49 (59.0%) were correctly identified by health providers (43 [51.8%] of which started bCPAP treatment), 23 (27.7%) were not identified as being bCPAP eligible, and 11 (13.3%) were missing identification information. Of the 52 infants who were not eligible for bCPAP, 45 (86.5 %) were correctly identified as not eligible and 46 (88.5 %) did not receive bCPAP.	The majority of infants survived to discharge (n=90, 66.2%). About one quarter of infants died (n=35, 25.7%). The remaining infants were either referred for tertiary care (n=3, 2.2 %) or had unknown outcomes (n=8, 5.9 %). Among the 43 bCPAP-eligible infants who started treatment, 18 (41.8%) survived. Among the 23 bCPAP-eligible infants who did not start treatment, 13 (56.5%) survived. No complications were reported
McAdams, 2015[14]	Uganda	Case series	Study included all 21 neonates admitted to a district hospital from January to June 2012 and treated with bCPAP. All neonates had RS Score ≥ 5. No exclusion criteria.	All 21 neonates were < 3 days old, all were treated with bCPAP, and 17/21 received bCPAP treatment within the first 24 hours of life.	16 of 21 infants were preterm (76%), 10 of 21 had birthweight < 1500g (48%), and 13 of 21 were outborn (62%). Birth asphyxia (24%) and RDS (76%) were the most common diagnoses. Average RSS score of 7.4 ± 1.3 before bCPAP decreased to 3.5 ± 1.9 while on bCPAP for an average of 79 ± 43 hours. 11 of 21 infants, or 52% survived to discharge. Complications included nasal irritation in 14% of neonates.
Ntigurirwa, 2017[23]	Rwanda	Retrospective Review	Study included 2206 neonates admitted to two district hospitals and 2135 neonates admitted to two university hospitals between February 2012 and January 2014.	During the first 18 months of the project, bCPAP was administered to 365 infants.	Survival rates for the 365 infants was not reported. Complications included transient nasal or facial trauma (13% of infants), significant abdominal distension (2% of infants), and technical problems (2% of infants).

There were no studies in the literature reporting on the incidence or indications for either mechanical ventilation or CPAP, complications to therapy, or disease-specific mortality in secondary hospital settings.

Numerous additional gaps in the literature were identified. No studies addressed nursing care outside of a LMIC tertiary care setting. No studies addressed the logistics of gas acquisition, blenders, or maintenance/hygiene concerns, in either secondary facilities or in tertiary facilities in LMIC, and only one study addressed physiologic issues and the variety of devices.[25] Altitude and other environmental factors were not addressed in the literature. Physician and staff education in disease management and details of training or retraining in bCPAP implementation were not discussed.

4. Discussion

CPAP applications have significantly altered newborn treatment and outcomes in high income countries, with a corresponding substantial decrease in the use of mechanical ventilation. High income countries have successfully developed devices, training programs, algorithms for utilization, and staff capacity for proper application of CPAP techniques.

CPAP and bCPAP use is increasing in LMIC, but appears limited to urban, tertiary care centers. There is a paucity of information in the medical literature regarding bCPAP use in secondary settings.

The three articles addressing the use of CPAP and bCPAP in secondary facilities report successful application of this technology in lower level settings in terms of equipment availability and function, monitoring during therapy, and discontinuation of therapy. Complications of therapy appeared to be limited. Difficulty with patient selection and timing of treatment initiation were noted. However, it is difficult to determine from these studies whether survival was improved or morbidity was decreased.

Reports from tertiary facilities in LMIC have implications for secondary facilities. Correct identification of newborns for whom bCPAP is appropriate is a significant challenge, but appears more acute at the secondary level. Sufficiently trained nursing staff is also a significant barrier to implementation. The availability of low-cost devices is another constraint to dissemination of CPAP, and several articles focused on new, inexpensive bCPAP devices. In terms of efficacy, reports from the tertiary hospitals have substantiated decreased mortality, superiority to ventilator CPAP, similar survival rates to ventilator treatment in properly selected newborns, simple algorithms for application, feasibility of utilization by nurses, and cost effectiveness. One study reported on the development of an algorithm for using bCPAP, which could help overcome selection difficulties. [24]

The normal barriers to implementation may be more acute in secondary facilities due to manpower, equipment supply chain, and staff training challenges. Overcoming these challenges requires additional implementation research efforts, and systems change.

There are also significant technical barriers that have not yet been addressed in the literature. Secondary facilities often struggle with respect to using blended gas, allowing the FiO2 to be appropriately varied, and this barrier is also impacted by the lack of non-invasive SpO2 monitoring in many secondary facilities in LMIC (and some tertiary facilities as well). A third barrier is availability of conditioned gas (warmed and humidified) as dry gases can desiccate the airway epithelium. A final barrier to discuss is the need for an effective nasal interface which is inexpensive, does not result in trauma to the nares and is sufficiently simple that the nursing staff can maintain that interface effectively.

5. Conclusion

There is evidence that bCPAP, when used in tertiary care settings in LMIC is feasible, safe, effective, reduces the need for

mechanical ventilation and ventilator CPAP, and may improve survival. In contrast, little is known about bCPAP safety, efficacy, implementation, and utilization in secondary care settings in LMIC, although these studies raise the possibility of successful implementation at this level of care. Additional research is needed to guide utilization in peripheral settings.

Conflicts of Interest: The authors have no conflicts of interests to disclose.

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