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Okonkwo IR
Okolo A

Bubble CPAP in Nigerian tertiary hospitals; Patented and improvised

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Okolo A (✉)
Okonkwo IR
Department of Child Health,
University of Benin Teaching Hospital,
Private Mail Bag 1111 Benin City
300001, Edo State, Nigeria.
Email: angelneneo@yahoo.com

Abstract*: Introduction*
Continuous Positive Airway Pressure (CPAP) is simple and effective new-born respiratory support. Early use reduces neonatal mortality. Given the high cost of the patented CPAP machines improvised CPAP devices are being used in resource poor settings.
Objectives: To ascertain the availability of CPAP devises, its use, and the types used in Nigerian tertiary hospitals.
Materials and methods: Ethical clearance and informed consent of respondents were obtained. The questionnaire surveyed the availability of the CPAP, training on provision of respiratory support and device and was administered to consenting participants at the 2015 Paediatric Association of Nigeria conference.
Results: 237 questionnaires were returned by respondents representing 54 health facilities from six geopolitical regions of Nigeria. CPAP devise was used in 72% of the evaluated facilities. These were mostly public (87%) tertiary hospitals (76%). Supplemental oxygen (37.6%) was the commonest mode of respiratory support followed distantly by CPAP (3.4%). Improvised CPAP training had been undertaken by 51% but the device was used by 47.7% of the respondents. Only 25.3% of the respondents had patented machines located in 33% of the facilities.
Conclusion: The use of patented and improvised CPAP services is high among respondents at the public tertiary health facilities.
CPAP services should urgently be taken to lower levels of health care so as to reduce neonatal deaths.

Key Words: Bubble CPAP; Nigerian tertiary; Patented; Improvised

Introduction

Since the discovery of continuous positive airway pressure (CPAP) by Gregory et al in 1971[1], several types of CPAP devices have been patented for use.[2] CPAP could be ventilator driven, stand alone bubble or flow driven.[2] CPAP is often thought to be the missing link between supplemental oxygen and mechanical ventilation.[1]CPAP strategy is technically simple and effective in managing new-born respiratory distress, an adjunct in the management of non-respiratory neonatal diseases with respiratory complications.[2]It is the first treatment of choice in many neonatal intensive care units (NICU) in developed countries and the non-invasive mode of respiratory support in the management of preterm very low birth weight babies.[3] It is also beneficial in conserving endogenous surfactant by maintaining functional residual capacity of the lungs.[2] Early use of nasal CPAP in preterm infants with respiratory distress syndrome (RDS) could decrease the need for subsequent intubation and mechanical ventilation.[4-6]

The patented CPAP machines though effective are expensive especially for many resource poor countries like Nigeria.[7,8] This has led to improvised CPAP devices for administering this intervention. These improvised devices deliver positive pressure to the airway of spontaneously breathing infants throughout the respiratory cycle albeit using high flow oxygen from cylinders or concentrators.

Improvised CPAP device in Nigeria has been described by Audu *et al* in 2013[9] and is used in many Nigerian tertiary hospitals. This device has been further modified for use in different clinical scenarios with available local resource.

CPAP delivery systems contain 3 major components. A gas source, which could be compressed oxygen in cylinders or concentrators blended with air; the effluent mixture is pre-warmed and humidified in the circuit. A circuit provides continuous flow of inspired gas to an interface, the nasal prongs are the most commonly used. The third component is a positive pressure generator. Bubble CPAP devices use a water column. The length of tube under water is equal to the positive end expiratory pressure. There is some evidence to suggest that the small vibrations produced in the infant's chest (at a frequency of 15–30 Hz) may facilitate gas exchange and decrease both the respiratory rate and minute ventilation, without

increasing the partial pressure of carbon dioxide (PCO_2).[10] The widespread use of this service will contribute to reduction in neonatal morbidity and mortality.

Objective

This study seeks to ascertain the availability of CPAP services, its utilisation and types available for use in tertiary hospitals in Nigeria.

Materials and methods

The proposal for this study was approved by the ethical committee of the University of Benin Teaching Hospital and informed consent was obtained from the attendees at Paediatric Association of Nigeria Conference (PANCONF) 2015 who agreed to participate. The process of field testing and validation were all conducted on the questionnaire before its use. This semi-structured validated questionnaire was administered to attendees during the 2015 edition of the Paediatric Association of Nigeria conference (PANCONF) that held in Abakaliki, Ebonyi state. The conference attendees were doctors and nurses of different cadre working in Paediatric and Neonatal facilities in Nigeria. Information about their practice location, trainings on CPAP services, and type of CPAP services available were solicited from the respondents.

The responses were weighted according to the status of the respondents and completeness of solicited information. Consultants with neonatal training were considered key informants. Limited demographic data were collected and the responses were anonymous.
The data gathered were entered into an IBM/ SPSS spreadsheet and analyzed.

Results

250 questionnaires were distributed during the conference out of which 237 were returned. The demographic distribution, designation, geopolitical distribution, religion, type and level of practice of the respondents are shown in Table 1.
Supplemental oxygenalone89(37.6%) is the most common respiratory support option available to the respondents, followed by supplemental oxygen and CPAP 67 (28.3%), supplemental oxygen, CPAP and Mechanical Ventilation (MV)32(13.5%). MV is the least available mode of respiratory support.
Table 2 shows the available Respiratory support options of respondents.

Table 1: General characteristics of the respondents

Characteristics		Number (%)	Total (%)
Gender	Male	90(38.0)	
	Female	147(62.0)	237(100)
Doctor	Consultant	96(40.5)	
	Senior Registrar	59(24.9)	
	Registrar	35(14.8)	
	Medical Officer	11(4.6)	201(84.8)
Nurse	ADNS	5(13.9)	
	CNO	5(13.9)	
	ACNO	5(13.9)	
	SNO	8(22.2)	
	NO-1	1(2.8)	
	NO-11	12(33.3)	36(15.2)
Geopolitical Region	South South	59(24.9)	
	South East	85(35.9)	
	South West	30(12.7)	
	North Central	43(18.1)	
	North East	3 (1.3)	
	North west	10 (4.2)	
	No response	7(3.0)	237(100)
Religion	Christianity	218(92.0)	
	Islam	16(6.8)	
	African traditional Religion	1(0.4)	
	No response	2(0.8)	
Type of practice	Public	208(87.8)	
	Private	26 (11.0)	
	No response	1(0.4)	
Level of practice	Primary	5(2.1)	
	Secondary	26 (11.0)	
	Tertiary	199 (83.9)	
	No response	2 (0.8)	

Table 2: Respiratory support options available to respondents

Respiratory support options	n (%)	Total
$^{ö}O_2$Supplemental oxygen	89 (37.5)	
^{ò}CPAP	8 (3.4)	
^{Ω}MV	4 (1.7)	
Supplemental $^{ö}O_2$ & CPAP	67 (28.3)	
CPAP & MV	2 (0.8)	
Supplemental O_2, CPAP& MV	32 (13.5)	202
No response	35 (14.8)	
	237 (100)	

^{ò}Continuous Positive Airway Pressure (CPAP)
^{Ω}Mechanical Ventilation (MV)
^{ö}Oxygen (O_2)

Improvised CPAP training has been undertaken by 121 (51%) of the respondents, 116(44.3%) were not trained while 10(4.6%) did not respond to the question. The use of the improvised CPAP was admitted by 113(47%) whereas 85(36.9%) did not use the devise.
The patented CPAP was used 60(25.3%) and 152 (64.1%) did not use the patented. Thirty nine out of 54 facilities (72%) evaluated used improvised or patented CPAP.

The distribution of the respondents by city, states are shown in Table 3. The distribution of patented CPAP devices use by geopolitical regions are shown in Table 4.

Table 3: Location of Respondents by Level of care, Type of practice and CPAP type available in their Neonatal units

State	City	Level of Care	Type of Practice	Type of CPAP	No of Patented CPAP
Abia	Umuahia	3^0	Public	Improvised/Patented	2
	Aba			Improvised	
Akwa Ibom	Uyo	3^0	Public	Improvised	
Anambra	Awka	3^0	Public	Improvised	
	Nnewi				
Bayelsa	Yenogoa	3^0	Public	Improvised	
Borno	Maiduguri	3^0	Public	Improvised/Patented	1
Cross River	Calabar	3^0	Public	Improvised	
Delta	Asaba	3^0	Public	Improvised	
	Warri	2^0	Private	Patented	1
	Oghara	3^0	Public	Patented	
Ebonyi	Abakaliki	3^0	Public	Improvised	
Edo	Benin City	3^0	Public	Improvised/ Patented	3
	Irrua	3^0	Public	Improvised	
Ekiti	Ado- Ekiti	3^0	Public	Improvised	
	Ido- Ekiti				
Enugu	Enugu	3^0	Public	Improvised	
Gombe	Gombe	3^0	Public	Patented	2
Imo	Owerri	3^0	Public	Improvised/Patented	2
	Orlu				
Kaduna	Zaria	3^0	Public	Improvised/Patented	2
Katsina	Katsina	3^0	Public	Patented	2
Lagos	Ikeja	3^0	Public	Improvised/Patented	1
	Idi-Araba			Improvised	
	Mainland	1^0		Improvised	
	Isolo	2^0	Private	Patented	
Nasarawa	Keffi	3^0	Public	Improvised	
Ogun	Abeokuta	3^0	Public	Improvised	
	Ilesha			Improvised	
Osun	Ile-Ife	3^0	Public	Patented	
Oyo	Ibadan	3^0	Public	Improvised	
Rivers	Port Harcourt	3^0	Public	Improvised	
	Bonny island	2^0*	Private	Patented	1
Sokoto	Sokoto	3^0	Public	Improvised/Patented	
Zamfara	Gusau	2^0	Public	Patented	
FCT	Abuja	3^0	Public	Improvised/ Patented	5
	Gwagwalada			Improvised	
	Abuja	2^0*	Public	Patented	1
	Abuja	2^0*	Private	Patented	7

*Some respondents from the group belong to the preceding category

Table 4: Geopolitical distribution of the Neonatal units by availability of Patented CPAP

Geopolitical Region	n (%)	Capital City (%)	Non capital City (%)	Public (%)	Private (%)	CPAP (%)
South-South	13(24.1)	8(61.5)	5(38.5)	10(76.9)	3(23.1)	4(30.7)
South-East	9(16.7)	6(66.7)	3(33.3)	9(100.0)	-	2(22.2)
South West	16(29.6)	7(43.8)	9(56.2)	13(81.3)	3(18.7)	3(18.8)
North Central	8(14.8)	6(75.0)	2(25.0)	7(87.5)	1(12.5)	3(37.5)
North East	2(3.8)	2(100)	-	2(100)	-	2(100)
North West	6(11.1)	5(83.3)	1(16.7)	6(100)	-	4(66.7)
	54	34(63)	20(37)	47(87)	7(13)	18(33)

Discussion

The use of the improvised CPAP device in health Institutions in Nigeria is expanding and has been well described in literature.[9,11,12] This improvised device became necessary due to the desire to help distressed newborn babies in a resource poor setting with effective low cost interventions.[13] This desire is enhanced by the availability of piped oxygen, oxygen cylinders and oxygen concentrators in many tertiary hospitals. There is a realisation that supplemental oxygen administration which is the standard of care in many health facilities provides inadequate respiratory support for many sick newborns with respiratory difficulty.[7,13]

The major common causes of newborn deaths in Nigeria; asphyxia, prematurity and sepsis compromise respiratory function, the cause and effect of which are preventable or treatable. These have accounted for the unacceptably high national Neonatal mortality rate.[14] Neonatal deaths occurring within the first few hours of life are preventable or treatable with bubble CPAP which is simple, effective and low cost.[1,13,15]

Supplemental oxygen is the most available and commonest mode of respiratory support (37.6%) of respondents in this nationwide survey. This level of support alone could salvage up to 25% of preterm babies with respiratory distress.[16] Supplemental oxygen is however more useful when the pressure component is added hence the development of CPAP services which could increase the salvage rate to 70%.[7]

Supplemental oxygen is still the most common mode of respiratory support at the facilities of respondents in this survey whereas the use of the CPAP device is now standard of care for new-born respiratory support in most developed countries.[3] Administration of 100% Oxygen is out of favour for resuscitation or support except otherwise strictly indicated. This is due to its neuro-respiratory effects especially in preterm babies. This has been overcome by the use of Air Oxygen/Blenders or Oxygen concentrators.

CPAP use in Nigerian health facilities among the respondents (72%) shows the wide spread use and acceptability of this intervention among healthcare workers in tertiary health centres in the country. This is a good sign of progress as this will improve the survival of distressed preterm babies treated with this intervention. But this service is shared amongst the patented and improvised CPAP device in our survey. The shortage of patented CPAP machines may be attributed to their high cost which is out of reach for many resource poor hospitals. The increasing need for neonatal respiratory support and awareness of this affordable alternative may be the driving force behind the use of this effective and improvised life saving device. It could cost less than $2 (#400) to assemble a unit. This maybe one of the cheapest improvised CPAP device compared to another low cost improvised bubble CPAP devise ($350).[17] The impact of the widespread use of this device in tertiary Nigerian hospitals requires thorough evaluation of its efficacy and requires further efforts to refine its use and improve its safety when the use of blended oxygen and air mixture can be resolved.

Only a quarter (25%) of the respondents had patented CPAP equipment while about half of the respondents (48%) use improvised CPAP device in this survey. Half of the respondents (51%) have been trained on setting up the improvised CPAP device hence a shortfall (3%) between those who are trained and the users of the device. This might be explained by availability of patented machines in some of the centres with persons

trained on the use of improvised CPAP devices.
It's also of note that some centres use both improvised and patented CPAP machines. The few numbers of patented CPAP machines available for use range from 1-7units per centre. Improvised device supplements the use of the patented CPAP machines in such centres. The centres that had fewer numbers of the patented machines improvised the more while the centre with the higher number of patented CPAP machines have enough to cater for their babies without improvising.

The few private centres represented in this survey utilised patented CPAP Devices. This is a huge investment in neonatal care and would be reflected on the cost of care as this service is not covered by the National health insurance scheme. The use of this modality of care will increase out of pocket spending of the clients.[11]These however represents only 2 of 54 (3.7%) health centres surveyed. Up to 52%of public tertiary centres used improvised CPAP devices for the care of babies in their facilities and only 33% had patented CPAP machines. This may be due to the prohibitive cost of the patented machines ($6000)[17,18]and poor funding of health infrastructure. Lack of these critical assets for care and life saving neonatal equipment may be the cause of poor decline in neonatal mortality in the past two decades. Introduction of this intervention in other locations have been shown to reduce neonatal mortality to less than 4 deaths per 1000 life-births.[19,20]

The higher proportion of health centres with patented CPAP from the North East and West regions of the country is deceptive as fewer health facilities were surveyed from the regions. This may be due to fewer numbers of conference attendees and respondents from these regions due to the prevailing security problems. The finding from the northern health facilities is not representative as they present the poorest neonatal health indices in the country.[14] Over 70% of the surveyed facilities are from the southern part of the country having half of the patented CPAP machines in public and private health centres. This may be one of the contributory factors to the better neonatal outcomes in the southern regions.

There is urgent need for the introduction and rapid dissemination of respiratory support services for new-born using the improved improvised CPAP devices in primary and secondary health facilities located in the communities where many of the new-born babies die from preventable and treatable conditions. The shift of the utilisation and implementation of this service from tertiary centres to the communities and its use and application should be task shifted from the neonatal paediatricians to medical officers, Nurses and community Health Extension Workers at the peripheral centres. This calls for urgent consensus for task shifting of this magnitude to be championed by the Professional Association. This is a sine qua non pillar and key to sustainable decline in the national Neonatal Mortality Rate.

There is an urgent need to address the policy for task shifting to enable the embracement of training for the various cadres of health care workers, so that it will be the driving force behind the establishment and equipping of neonatal units with CPAP devices; patented and improvised. It is the simple, low cost and effective solution for good neonatal outcomes.

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References

1. Gregory GA, Kitterman JA, Phibbs RH, Tooley WH, Hamilton WK. Treatment of the idiopathic respiratory-distress syndrome with continuous positive airway pressure. *N Engl J Med 1971; 284:1333–1340.*
2. Robert MD: Nasal Continuous Positive Airway Pressure (CPAP) for the Respiratory Care of the Newborn Infant. *Respir care 2009; 54:1209-1235.*
3. Finer NN. Early CPAP versus Surfactant in Extremely Preterm Infants. *New England J Med 2010; 362: 2235–2235.*
4. Poets CF, Sens B. Changes in intubation rates and outcome of very low birth weight infants: a population-based study. *Pediatrics 1996; 98(1):24–27.*
5. Gitterman MK, Fusch C, Gitterman AR, Regazzoni BM, Moessinger AC. Early nasal continuous positive airway pressure treatment reduces the need for intubation in very low birth weight infants. *Eur J Pediatr 1997;156(5):384–388.*
6. Lindner W, Vossbeck S, Hummler H, Pohlandt F. Delivery room management of extremely low birth weight infants: spontaneous breathing or intubation? *Pediatrics 1999;103(5 Pt 1):961–967.*
7. Kamath BD, MacGuire ER, McClure EM, Goldenberg RL, Jobe AH. Neonatal Mortality From Respiratory Distress Syndrome: Lessons for Low Resource Countries. *Pediatrics 2011: 127: 1139–1146.*
8. Chen A, Deshmukh AA, Richards-Kortum R, Molyneux E, Kawaza K, Cantor SB.Cost-effectiveness analysis of a low-cost bubble CPAP device in providing ventilatory support for neonates in Malawi – a preliminary report. *BMC Pediatrics 2014; 14:288*
9. Audu LI, Otuneye AT, Mukhtar MY, Mairami AB, Mshelia LJ, Garu M. Customized bubble continuous airway pressure device at the National Hospital Abuja for the treatment of respiratory distress syndrome (RDS). *Niger J Paediatr 2013; 40(3)275-277.*
10. Steven MD, Sunil KS. Invasive and Noninvasive Neonatal Mechanical Ventilation. *Respir Care 2003; 48(4):426–439.*

11. Audu LI, Otuneye AT, Mairami ABK, Mukhtar MY. Improvised bubble continuous positive airway pressure (bCPAP) device at the National Hospital Abuja gives immediate improvement in respiratory rate and oxygenation in neonates with respiratory distress. *Niger J Paediatr 2015; 42 (1): 12 –16.*
12. Abdulkadir I, Abdullahi F, Hassan L, Purdue S, Okpe M, Mohammed A et al. The Use of bubble nasal CPAP in the management of IRDS -A Case report and literature review. *Niger J Paediatr 2013; 40 (3): 303 –306.*
13. Chen A, Deshmukh AA, Richards-Kortum R, Molyneux E, Kawaza K, Cantor SB. Cost-effectiveness analysis of a low-cost bubble CPAP device in providing ventilatory support for neonates in Malawi-a preliminary report. *BMC Paediatrics 2014,14;288.*
14. Federal Ministry of Health. Saving newborn lives in Nigeria: Newborn health in the context of the Integrated Maternal, Newborn and Child Health Strategy. 2nd edition. Abuja: Federal Ministry of Health, Save the Children, Jhpiego; 2011.
15. Lawn JE, Cousens S, Zupan J. 4 million neonatal deaths: when? Where? Why? *Lancet 2005; 365:891-900.*
16. Lanman JT, Guy LP, Dancis J. Retrolental fibroplasia and oxygen therapy. *J AM Med Assoc. 1954;155(3):223–226.*
17. Brown J, Machen H, Kawaza K, Mwanza Z, Iniguez S, Lang H, et al. A High-Value, Low-Cost Bubble Continuous Positive Airway Pressure System for Low-Resource Settings: Technical Assessment and Initial Case Reports. PLoS ONE 8 (1): e53622. doi:10.1371/journal.pone.0053622.
18. Watson AD (2010) Premarket Notification Decision for Fisher & Paykel Healthcare Bubble CPAP System. U.S. Food and Drug Administration: 510 (k) Number K100011. Available: http://tinyurl.com/k100011.
19. Mathews T, Mac Dorman M. Infant mortality statisticsfromthe2006periodlinkedbirth/infant death data set. *Natl Vital Stat Rep. 2010;58(17):1–31*
20. Lussky R. A century of neonatal medicine. *Minn Med. 1999;82(12):48–54.*