THREE-YEAR EXPERIENCE WITH NEONATAL VENTILATION FROM A TERTIARY CARE HOSPITAL IN DELHI

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ABSTRACT

Ninety neonates were ventilated over a period of 33 months of whom 50 (55.5%) survived. Fifty seven babies received IPPV while 33 CPAP. IPPV mode was being used more frequently recently and survival rates have steadily improved over past 3 years. Survival was cent per cent in babies above 1.5 kg on CPAP mode while 16/26 (57.7%) survived on IPPV mode. Of 22 extremely VLBW (<1 kg) babies, six survived. HMD was the commonest indication of ventilation (50%), of which 53% (24/45) survived. The other important indications of ventilation were apnea in 13 and transient tachypnea in 11 babies. All babies requiring ventilation for transient tachypnea survived. Nosocomial infections were common in association with ventilation 34/90 (37.7%), out of which in 14 was responsible for about a third of deaths. Pulmonary air leaks developed in 12 babies of which 6 died. Two babies developed BPD and one ROP.

Neonatal ventilation should be ventured in centres where basic facilities for level II care already exist. It may not be cost effective to ventilate extremely low birth weight neonates.

Key words: *Neonatal ventilation, Hyaline membrane disease.*

Neonatal assisted ventilation has revolutionized the outcome of sick newborns in intensive care units. Respiratory disorders are the commonest cause of major neonatal morbidity requiring intensive care(1). They account for the single most important pathological finding in neonatal autopsy studies(2). In our country, the incidence of respiratory distress reported varies from 4-7 per 100 live births. Hyaline membrane disease (HMD) is the leading cause of respiratory distress accounting for one-third of cases(1). Respiratory distress syndrome (hyaline membrane disease) is the commonest disorder requiring assisted ventilation both in developed and developing countries(3-8). The scene of assisted neonatal ventilation in our country is quite dismal. Even majority of medical colleges lack the basic infrastructure to ventilate sick children what to talk of neonates. There is, therefore, scanty published data on neonatal mechanical ventilation from our country(4,5). Present study was undertaken to identify the indications and complications of assisted ventilation in neonates.

Material and methods

Records of neonates who required assisted ventilation were analysed using a computer database Epi-Info programme. Babies who required short term ventilation

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Received for publication: December 2, 1992; Accepted: February 24, 1993

(<6 hours) for severe birth asphyxia and babies who required ventilation for surgical congenital malformations were excluded from the analysis. All babies were born in our hospital and all deliveries were attended by a trained pediatrician.

During a period of 2 years 9 months (January 1989 to September 1991), 90 neonates required assisted ventilation in the form of CPAP or IPPV. They were managed with a fixed standard protocol which were followed in our neonatal unit (as below):

A. *Indications for CPAP*

1. Progressive respiratory distress with inability to maintain arterial blood gases with a FiO_2 of 0.6, (pH<7.25 and/or PaO_2 <50 mm Hg, and/or $PaCO_2$ >60 mm Hg).
2. Prolonged or recurrent apneic spells in a preterm baby with normal lung parenchyma.

CPAP was administered by nasal prongs or endotracheal tube. Endotracheal route was used in all babies weighing <1 kg.

B. *Indications for IPPV*

1. *Failure of CPAP:* Inability to maintain normal blood gases at FiO_2 0.6 and CPAP 10-12 cm by prongs or 8-10 cm by endotracheal route or repeated apneic spells on CPAP or worsening respiratory distress.
2. Babies weighing <1 kg and suffering from severe birth asphyxia and developing respiratory distress.
3. *Cardiovascular collapse:* Majority of babies were weaned off from IPPV-IMV-CPAP mode. Typical initial settings for CPAP and IPPV are shown in *Table I.*

Time cycled, pressure-limited, continuous flow ventilator (Sechrist-100B infant ventilator with varying PIP, PEEP, Flow rates, Ti and FiO_2 were used. The settings of the ventilator were governed by underlying disease and acid base gasometry (ABG).

TABLE I–*Typical Initial Ventilator Settings*

CPAP mode* (endotracheal)

(*a*) Apnea with normal lung–Pressure 5 cm of water, FiO_2 0.4

(*b*) HMD in preterm–Pressure 5 cm of water, FiO_2 0.5

*Use 2-3 cm higher pressure for nasal route

IPPV Mode

	Apnea with normal lung	HMD in preterm <1.3 kg	MAS term baby
PIP cm	13-14	16-18	15-16
PEEP cm	4-5	5	3
Flow rate L/min	5-8	5-8	5-8
FiO_2	0.4	0.5	variable
Ti sec	0.35	0.5	0.3-0.4
RR/min	10-15	50-60	variable

All babies were nursed under servo controlled open care system. Radial or umbilical artery or arterialized capillary ABGs were done as and when required. In 20 cases low umbilical artery lines were put to record continuous blood pressure and for taking blood samples. All babies were hooked on to continuous oxygen saturation monitors (Ohemeda-Biox, Invivo, Criticare) and oxygen saturation was maintained between 87-95%. In addition continuous heart rate or electrocardiographic recordings were made in all babies.

After initial stabilization (2-3 days) babies on IPPV received enteral feeds (expressed breast milk). It was gradually stepped up over several days and stopped on the day of planned extubation. In the event of intolerance to feeds or suspicion of NEC TPN was resorted to (5 babies). Enteral feeds were not given to babies on CPAP.

The aim of assisted ventilation was to maintain normal ABGs with minimal work of breathing at lowest possible ventilator settings. Extubation was planned if babies maintained arterial oxygen saturation and ABGs at minimal settings of IMV (Rate 10-15/min, FiO_2 0.4, PIP 13-15 cm, PEEP 3-4 cm, Ti 0.35 sec). Before extubation babies were weaned to CPAP mode (4-8) and then put under oxygen hood with FiO_2 0.5. Aminophylline was used before extubation if IPPV duration was >72 hours while dexamethasone (1-2 doses) was used at the discretion of consultant on call. For babies on CPAP mode, CPAP was decreased in steps of 1 cm and FiO_2 0.05 till CPAP pressure of 3-4 cm with FiO_2 0.4 were reached. The babies from CPAP mode were then shifted to oxygen by hood with FiO_2 of 0.5.

Babies were started on antibiotics if septic screen (CRP, TLC, band cell count, ESR) was positive or there were predisposing factors for development of infection(1). Skiagrams of chest were obtained after each tube change or whenever sudden deterioration occurred or routinely every day during first seven days and then as and when required. Chest physiotherapy, with frequent postural changes were resorted to in case of development of pneumonitis. Endotracheal suction was done routinely after 48 hours of intubation every 4 to 6 hours with complete aseptic care.

The cause of death was assigned according to the classification of Nakamura *et al.* and Wigglesworth with minor modifications to suit Indian settings(2), by a team at least two consultants after taking autopsy report into account.

Hyaline membrane disease: Diagnosis of HMD was made when a preterm baby developed increasing respiratory rate with retractions and grunting. The onset of distress occurred within 6 hours with increasing oxygen requirements in order to maintain oxygenation during first 48-72 hours. Negative gastric aspirate shake test and suggestive chest roentgenograms wherein aspiration and intrauterine pneumonia could be excluded supported the clinical diagnosis(10). Histopathological examination showing atelectasis in an unaerated area and/or eosinophillic hyaline membranes in the aerated area confirmed the diagnosis(10).

Transient tachypnea of the newborn: The diagnosis was based on exclusion of other known causes of respiratory distress such as HMD, pneumonia, aspiration, *etc.* The neonates required minimal FiO_2 and oxygen requirements came down quickly. The condition was seen in both preterm and term babies most probably related to delayed absorption of lung fluid. Roentgenogram of chest showing normal lung

parenchyma and occasionally prominent interlobar fissure with minimal cardiac enlargement.

Apnea: Cessation of breathing for a period of 20 seconds or if <20 seconds but associated with bradycardia or cyanosis(11). All efforts were made to find out the cause and in cases of secondary apnea the condition was managed specifically depending upon the underlying cause.

Immaturity: Babies weighing less than 750 g, in whom no other primary cause of death could be ascertained, were judged to have died of immaturity. They had immature lungs (manifesting as respiratory failure) and brain (manifesting as recurrent apnea and IVH). Death usually occurred within 24-72 hr of birth.

Septicemia: It was diagnosed in babies with or without high risk perinatal factors (PROM 24 h, maternal fever, chorioamnionitis) and in whom blood or cerebrospinal fluid culture was positive in addition to clinical features of speticemia. Babies with sterile blood culture were labelled as cases of probable sepsis if the clinical features and septic screening tests were suggestive of septicemia.

Results

A total of 90 neonates were ventilated during 21 months period. IPPV was used more commonly during 1991, while CPAP was the common mode of ventilation in 1989 (*Table II*). Mode of ventilation and year wise distribution in relation to birth weights are depicted in *Table II*. Duration of ventilation was <24 h in 19, >24 - <72 h in 30, >72 - <168 h in 29 and >168 h in 12 babies. All babies needing >168 h ventilation were on IPPV mode. The smallest baby who survived IPPV was born at 26 weeks with a birth weight of 830 g. He needed ventilation for 510 h. The longest duration of 48 days of ventilation was given to a baby weighing 800 g, born after 28 wks gestation, who ultimately died due to NEC, BPD and sepsis. Common indications for ventilation included HMD 45/90, apnea 13/90 and TTNB 11/90. The indications and mode of ventilation are shown in *Table III*.

Pneumothorax developed in nine babies of which three survived. It was an assigned cause of death in four babies. Sepsis was the commonest complication and it occurred in 34 cases of which 20 had underlying pneumonia. It accounted for 14/40 (35%) deaths. IVH developed in 19 which proved fatal in 8. The causes of deaths are listed in *Table IV*. Pulmonary air leak occurred in 12 patients (9 pneumothorax, 4 PIE, 2 pneumomediastinum). Bronchopulmonary dysplasia developed in two, retinopathy of prematurity and, necrotizing enterocolitis in one each. Persistent pulmonary hypertension (persistent fetal circulation) developed in five infants on IPPV.

Discussion

Assisted ventilation is the single most important advancement in neonatal medicine which has reduced neonatal mortality. From early seventies, IPPV for respiratory failure in the newborn has become reality in neonatal intensive care units in the West (12). HMD was the commonest (50%) indication for ventilation in the present study, followed by apnea 13/90 and TTNB 11/90.

Gregory introduced CPAP by head box or endotracheal tube for management of RDS(13). It is known that early CPAP treatment of neonates with RDS may avoid subsequent need for mechanical ventilation(14). Five years ago, we were satisfied

TABLE II–*Mode of Ventilation*

	Total		1989		1990		1991	
	Survival	(%)	Survival	(%)	Survival	(%)	Survival	(%)
IPPV	25/57	(43.8)	4/14	(28.6)	9/20	(45.0)	12/23	(52.2)
CPAP	25/33	(75.7)	14/15	(93.3)	9/15	(60.0)	2/3	(66.7)
Total	50/90	(55.5)	18/29	(62.1)	18/35	(51.4)	14/26	(53.8)

TABLE III–*Birth Weight Groups and Mode of Ventilation*

	CPAP			IPPV		
Weight groups	n	survived	(%)	n	survived	(%)
< 1000 g	4	2	(50)	18	4	(22.2)
> 1000-< 1500 g	15	9	(60)	13	5	(38.4)
> 1500-< 2500 g	13	13	(100)	21	13	(62)
> 2500 g	1	1	(100)	5	3	(60)
Total	33	25	(75.8)	57	25	(44)

TABLE IV–*Survival in Relation to Indication of Ventilation: Mode and Year Wise Distribution*

	CPAP		IPPV		1989		1990		1991	
Indication	n	Survivors	n	Survivors	n	Survivors	n	Survivors	n	Survivors
HMD	15	11	30	13	17	8	18	9	10	7
Apnea	5	3	8	5	3	3	5	2	5	3
TTNB	9	9	2	2	5	5	5	5	1	1
HIE	-	-	7	1	1	0	3	1	3	0
Immaturity	1	0	2	0	-	-	1	-	2	0
MAS	-	-	1	0	-	-	1	0	2	0
PDA	2	1	3	2	1	1	1	0	3	2
Opiate	-	-	1	1	-	-	1	1	-	-
Pneumonia	1	1	2	1	2	1		-	1	1
Sepsis	-	-	1	0	-	-	-	-	1	0
Total	33	25	57	25	29	18	35	18	28	14

using face mask for CPAP(5). With advances in our technical expertise we are now using nasal prongs or endotracheal tube for CPAP. CPAP was given in 33 infants of whom 25 survived. Experience over the last 3 years has shown that CPAP trial should be given to HMD babies weighing 1.0-1.5 kg before shifting them to IPPV

mode. Babies above 1.5 kg do fairly well on CPAP alone if they have mild to moderate HMD. The survival rate of nearly 100% for HMD above birth weight of 1.5 kg support above recommendation (*Table III*). Babies below 1 kg invariably failed on CPAP and required IPPV with poor outcome (4/18 survived). CPAP mode was useful for the treatment of idiopathic apnea of prematurity (obstructive) and supporting ventilation in secondary apnea till cause was reversed. TTNB babies were successfully managed with CPAP and all of them survived. Complications like pulmonary air leak, BPD, ROP were uncommon on CPAP mode.

Judicious use of IPPV improves the outcome in babies with moderate to severe HMD. It should be used early in the course of disease before metabolic complications have set in or organ (heart, brain, kidney) damage has occurred. The risk of immediate death should be weighed against the outcome of conservative approach or aggressive approach with IPPV with attendant complications and neurological sequelae. The indications and treatment protocols should be laid down to achieve best results.

IPPV is not without complications. Pulmonary air leaks are common and these can be diagnosed early by urgent skiagrams or transillumination(15). Twelve (13%) patients developed some form of air leaks and it proved fatal in six. Early judicious management of pneumothorax may salvage a critically sick neonate. Prolonged ventilation is associated with bronchopulmonary dysplasia(16-19) and retinopathy of prematurity, which were seen in two and one patient, respectively.

The aim of ventilation should be to use minimal FiO_2 for shortest duration with lowest possible pressure so as to maintain oxygenation. Nearly 35 babies developed infection during ventilation, majority being nosocomial. Steps to ensure asepsis are of paramount importance otherwise all efforts are doomed to failure. Early orogastric feeding with expressed breast milk, judicious use of appropriate antibiotics, liberal use of disposable material, and other strategies to prevent nosocomial infections are highlighted in another review(20).

Ventilation for babies weighing <1 kg may not be cost effective as invariably IPPV mode is required for a prolonged period with poor outcome. Four of 18 babies weighing <1 kg who survived, one had ROP and two developed BPD. Over the years with increasing experience, and confidence in the use of IPPV, CPAP use has decreased. The case survival rates have shown improvement. The salvage of tiny babies is difficult and may be related to immaturity of other organs in addition to lungs.

The success of assisted ventilation lies in devotion, continuous involvement of trained, skilled and committed team consisting of nursing staff, biochemist, physiotherapist and neonatologist.

Acknowledgements

The authors gratefully acknowledge the outstanding contribution of Prof. D. Vidyasagar and Dr. Vinod Bhutani in helping them learn the concepts of neonatal ventilation.

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