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Clinical profile and outcome of mechanically ventilated children in pediatric intensive care unit at a tertiary care hospital

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Abstract
Background: Mechanical ventilation refers to artificial methods used for supporting ventilation and oxygenation. With the advent of mechanical ventilation, the intensive care for pediatric patients have witnessed high success rates, better management of complications and improved outcomes with reduced mortality and morbidity rates. This study was done to assess the preceding risk factors, indication, clinical profile and outcome of mechanically ventilated children from rural population admitted in a tertiary care hospital.
Methods: Prospective observational study of critically ill cchildren between 2 months and 12 years of age who required mechanical ventilation in Pediatric Intensive Care Unit of a tertiary care hospital. The data collected includes epidemiological profile, risk factors, clinical, laboratory and mechanical ventilation profile.
Results: A total of 70 children required mechanical ventilation .The mean ± SD age of the participants was 2.05 ±2.4 years. Bronchopneumonia was the most common diagnosis (n=20, 28.6%) and the most common indication for mechanical ventilation among the study participants was severe respiratory distress (n=23, 32.9%).The most common complication observed among the study participants was Ventilator associated pneumonia (n=21, 30%). Overall, majority of the participants survived (n=44, 62.9%) while 26 (37.1%) participants expired in this study.
Conclusion: Majority of the children were less than 1 year of age from poor socio economic status. Respiratory causes like bronchopneumonia and bronchiolitis were the common conditions requiring mechanical ventilation. More analytical studies are needed in future, to estimate the long term sequelae and outcome in mechanically ventilated children.

Keywords: Mechanical ventilation, ventilator associated pneumonia, bronchopneumonia

Introduction
Globally, it has been estimated that the leading cause of childhood mortality include preterm birth complications, pneumonia, congenital anomalies, diarrhoea and other infectious diseases [1]. Based on WHO data, pneumonia and other respiratory conditions are the leading causes of mortality in children (14%) while asphyxia and pneumonia constituted 13% of neonatal deaths [2].
Acute respiratory failure is often the common complication developing in respiratory infections, poisoning, envenomation, neurological diseases, neuromuscular disorders and congenital anomalies. Children admitted in Pediatric Intensive Care Unit with acute respiratory failure due to any cause needs Mechanical Ventilation (MV) as the mainstay therapy along with other supportive treatment [3]. For the last few decades, management of mechanically ventilated children had improvised better with various standard treatment protocols. With the advent of mechanical ventilation, the intensive care for pediatric patients have witnessed high success rates, better management of complications and improved outcomes with reduced mortality and morbidity rates.
Although many studies have been done in the past about the profile of PICU admissions for mechanical ventilation in children, I have taken this study to assess the preceding risk factors, indication, clinical profile and outcome of mechanically ventilated children from rural population admitted in a tertiary care hospital.

Methods
This is a Prospective observational study, carried out in Pediatric Intensive Care Unit (PICU), Department of pediatrics, Rajah Muthiah Medical College and Hospital (RMMCH),

Chidambaram, among Children between 2 months and 12 years of age who required endotracheal intubation and mechanical ventilation from October 2018 to April 2020.

A structured pro forma was used to obtain data which includes epidemiological profile, risk factors, clinical, laboratory and mechanical ventilation profile. Mechanical ventilator settings are initiated by standard protocol depending on the disease condition. The settings are titrated according to the disease progression. The children are constantly monitored. Investigations like complete blood count, blood glucose, C – reactive protein, serum electrolytes, renal function tests, blood gases, chest x ray, endo tracheal tube culture and pro thrombin time are done and repeated when needed. Weaning from mechanical ventilation is decided according to the disease progression. Complications of the disease are noted.

Data were entered and analyzed using SPSS ver.2.0 software. The prevalence of epidemiological profile, risk factors and clinical profile including disease diagnosis, indications, duration and complications of mechanical ventilation along with laboratory parameters and supportive treatment, were expressed as percentages. The outcomes of MV were expressed as percentages. Chi square test was used to evaluate the association between the categorical data. Independent sample t test was used to evaluate the association between measurement data. A p value< 0.05 was considered statistically significant.

Results

The present study was carried out among 70 children who were treated with mechanical ventilation in our tertiary care hospital during the study period. The mean ± SD age of the participants was 2.05±2.4 years. Majority of the participants were less than one year of age (n=35, 50%) followed by 1-5 years (n=30, 42.9%). Majority of the study participants were females (n=37, 52.9%) and (n=33, 47.1%) of the participants were males.

The risk factors among the study participants are outlined in table1. It was observed that bottle feeding and low socioeconomic status were the predominant risk factors (n=32, 45.7%) followed by neonatal non-invasive ventilation (n=25, 35.7%). The other common risk factors included poor sanitation (n=15, 21.4%) and overcrowding (n=13, 18.6%).

Table 1: Risk factors among the study participants

S. No	Factors	Frequency (n=70)	Percentage (%)
1	Past history of hospitalization	12	17.1
2	Antenatal TORCH infections	nil	
3	Gestational Diabetes Mellitus	20	28.6
4	Pregnancy Induced Hypertension	11	15.7
5	Prematurity	4	5.7
6	Birth asphyxia	6	8.8
7	Meconium Aspiration Syndrome	0	0
8	Neonatal non invasive ventilation	25	35.7
9	Neonatal invasive ventilation	nil	
10	Neonatal seizures	4	5.8
11	Recurrent aspirations	nil	
12	Developmental delay	4	5.8
13	Unimmunized	nil	
14	Partially immunized	1	1.4
15	Bottle feeding	32	45.7
16	Family history of atopy	nil	
17	Family history of tuberculosis		
18	Family history of seizures	nil	
19	Family history of unexplained death		
20	Low socioeconomic status	32	45.7
21	Overcrowding	13	18.6
22	Poor sanitation	15	21.4
23	Katcha house	15	21.4

Symptomatology at the time of presentation

The common clinical symptoms at the time of presentation are provided in table 2. Fever was the most common symptom (n=45, 64.3%) among the study participants followed by difficulty in breathing (n=44, 62.9%) and lethargy (n=43, 61.4%). The other commonly presented symptoms included cough (n=38, 54.3%) and refusal of feeds (n=21, 30%).

Table 2: Symptomatology at the time of presentation

S. No	Symptoms	Frequency (n=70)	Percentage (%)
1	Cough	38	54.3
2	Difficulty in breathing	44	62.9
3	Fever	45	64.3
4	Headache	8	11.4
5	Vomiting	7	10
6	Lethargy	43	61.4
7	Irritability	4	5.8
8	Refusal of feeds	21	30
9	Abnormal movements of upper limbs and lower limbs	15	21.4

10	Pain over the sting or bite site	7	10
11	Swelling over the sting or bite site	4	5.8
12	Excessive salivation	7	10
13	Excessive sweating	8	11.4
14	Blurred vision	6	8.6
15	Abdominal pain	5	7.1
16	Diarrhoea	2	2.8
17	Muscle weakness	3	4.3

Clinical signs among the study participants

The predominant clinical sign observed among the study participants was tachycardia (n=67, 95.7%) and tachypnea (n= 52, 87.1%) followed by reduced levels of oxygen saturation (n=52, 74.3%). (Table 3)

Table 3: Clinical signs among the study participants

S. No	Signs	Frequency (n=70)	Percentage (%)
1	Normal respiratory rate	0	0
2	Tachypnoea	61	87.1
3	Bradypnea	7	10
4	Apnoea	2	2.9
5	Decreased oxygen saturation (<90 %)	52	74.3
6	Increased capillary filling time (>3 seconds)	14	20
7	Normal heart rate	0	0
8	Tachycardia	67	95.7
9	Bradycardia	3	4.3
10	Compensated shock	3	4.3
11	Hypotensive shock	20	28.6
12	Alert	7	10
13	Voice responsive	4	5.7
14	Pain responsive	37	52.8
15	Unresponsive	12	17.1
16	Seizures	19	27.1
17	Unequal pupil	0	0
18	Pinpoint pupil	5	7.1
19	Dilated pupil	1	1.4
20	Bite mark	3	4.3
21	Sting mark	6	8.6
22	Cellulitis	5	7.1
23	Excessive sweating	9	12.8
24	Excessive salivation	7	10
25	Cold peripheries	26	37.1
26	Bleeding diathesis	1	1.4

Clinical diagnosis among the study participants

The clinical diagnosis among the study participants is given in table 4. Bronchopneumonia was the most common diagnosis (n=20, 28.6%) followed by bronchiolitis (n=18, 25.7%) among the study participants. The other causes included Refractory status epilepticus (n= 7, 10 %) scorpion sting envenomation (n=6, 8.6%) and acute viral encephalitis (n=5, 7.1%), but this was statistically insignificant. (chi sq=2.7, p=0.437).

Table 4: Clinical diagnosis among the study participants

S. No	Diagnosis	Frequency (n=70)	Percentage (%)	p value
Respiratory Causes				
1	Bronchopneumonia	20	28.6	
2	Bronchiolitis	18	25.7	
Neurological Causes				
3	Acute bacterial meningitis	2	2.9	
4	Acute viral encephalitis	5	7.1	
5	Refractory status epilepticus	7	10	
Toxins				
6	Scorpion sting envenomation	6	8.6	0.453
7	Snakebite envenomation	3	4.3	
8	Organophosphorus Compounds poisoning	3	4.3	
Other Causes				
9	Acute gastroenteritis with hypovolemic shock	2	2.9	
10	Nephrotic syndrome with septic shock	1	1.4	
11	Astrocytoma with increased intracranial tension	1	1.4	
12	Hypertrophic Cardiomyopathy	1	1.4	
13	Diabetic Ketoacidosis with cerebral oedema	1	1.4	
Total		70	100	

Indication for mechanical ventilation among the study participants

The most common indication for ventilation among the study participants was severe respiratory distress (n=23, 32.9%) followed by respiratory failure (n=13, 18.6%) and decompensated shock (n=8, 11.4%). More than one indication was present in 28.6 % (n=20) of the study participants. (Table5). With p value of 0.001, this is statistically significant. (Chi sq=21.3, p=0.001).

Table 5: Indication for mechanical ventilation among the study participants

S. No.	Indication	Frequency (n=70)	Percentage (%)	p value
1	Severe respiratory distress	23	32.9	0.001
2	Respiratory failure	13	18.6	
3	Decompensated shock	8	11.4	
4	Cardiac arrest	2	2.9	
5	Refractory status epilepticus	4	5.7	
6	More than one of above indication	20	28.6	
Total		70	100	

Duration of mechanical ventilation among the study participants

The average duration of ventilation among the study participants was 3.4±2.5 days. Majority of the participants were on ventilation for less than two days (n=39, 5.7%) while 40% of the participants were on ventilatory support for three to seven days. (Figure 1)

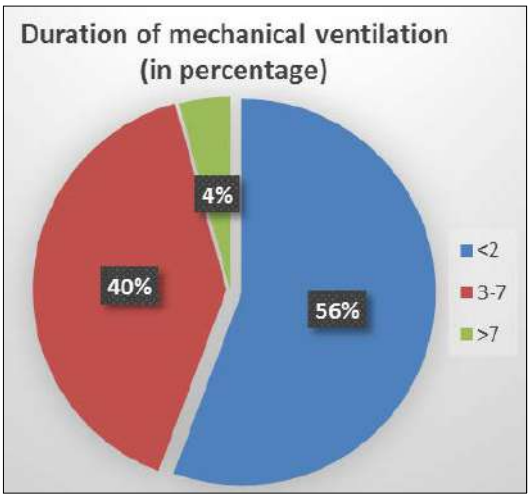

Fig 1: Duration of mechanical ventilation among the study participants

Complications during mechanical ventilation among the study participants

The most common complication observed among the study participants was Ventilator associated pneumonia (n=21, 30%) followed by displacement of endotracheal tube. About 70 %(n=49) of the study participants did not report any complications. (Table 6)

Table 6: complications during mechanical ventilation among the study participants

S. No.	Complications	Frequency (n=70)	Percentage (%)
1	Ventilator Associated Pneumonia	21	30
2	Displacement of endotracheal tube	6	8.8
3	Obstruction	4	5.8
4	Pneumothorax	2	3
4	No complications	46	70

Laboratory Profile of the Study Participants

The predominant laboratory parameters evaluated in this study were total counts, C-reactive protein levels, arterial blood gas analysis, culture analysis of the endotracheal tube and chest X-ray before and during the ventilation. It was observed that total counts were elevated in 91.4 % (n=64) of the participants (chi sq=0.04, p=0.841), while C-reactive protein was elevated in 68.6% (n=48) of the participants (chi sq=2.8, p=0.091), but this was statistically insignificant. Majority of the participants demonstrated either respiratory (44.3%, n=31) or metabolic (32.8%, n=23) acidosis. With p value of 0.0001, this is statistically significant. (Chi sq=34.4, p=0.0001).

Chest X ray taken prior to the intubation showed that 25.7 %(n=27) of the participants had hyperinflation and 17.1 %(n=15) had pulmonary oedema, but this was statistically insignificant (chi sq=2.3, p=0.129). Only 38.6 %(n=27) of the chest X-rays were normal. However, in the subsequent x rays, 62.8 %(n=44) of the X-rays were normal, while 37.1 %(n=26) showed pneumonic infiltrates. (Table 13). With p value of 0.0001, this is statistically significant. (Chi sq=13.3, p=0.0001). The Endo tracheal tube cultures were positive for Multidrug resistant staphylococcus aureus (MRSA), Vancomycin Resistant Staphylococcus aureus (VRSA), Klebsiella and E. Coli.No growth was found in 51.4% of the participants. This was clinically significant. (Chi sq=23, p=0.0001).

Table 7: Laboratory profile of the study participants

S No.	Laboratory profile		Frequency (n=70)	Percentage (%)	P value
1	Total counts	Elevated	64	91.4	0.841
		Normal	6	8.6	
2	C-Reactive Protein	Normal	22	31.4	0.091
		Elevated	48	68.6	
3	Arterial Blood Gas	Normal	16	22.9	0.0001
		Respiratory acidosis	31	44.3	
		Metabolic acidosis	23	32.8	
4	Endo tracheal tube culture	No growth	36	51.4	0.0001
		Methicillin resistant staphylococcus aureus (MRSA)	12	17.1	
		Vancomycin Resistant Staphylococcus aureus (VRSA)	10	14.3	
		Klebsiella	10	14.3	
		E. coli	2	2.9	
5	Chest X Ray before ventilation (CXR1)	Normal	27	38.6	0.129
		Hyperinflation	27	25.7	
		Pneumonitic infiltrates	12	4.3	
		Pulmonary oedema	15	17.1	
		Cardiomegaly	1	1.4	
6	Chest X ray with ventilation (CXR2)	Normal	44	62.8	0.0001
		Hyperinflation	9	8.6	
		Pneumonitic infiltrates	26	37.1	
		Consolidation	24	34.3	
		Cardiomegaly	1	1.4	

Frequency of Complications of the Disease among the Study Participants

The common disease complications encountered among the study participants on mechanical ventilation were refractory shock (n=31, 44.3%), septicaemia (n=22, 31.4%) and multi-organ dysfunction syndrome (n=22, 31.4%).

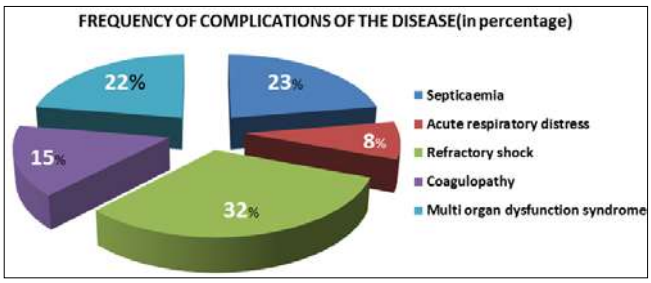

Fig 2: Frequency of complications of the disease among the study participants

Supportive Treatment Received by the Study Participants

While almost all the participants were treated with inotropes and antibiotics, anti-epileptics were required in 34.3 % (n=24) of the participants. (Table 15)

Table 8: Supportive treatment received by the study participants

Supportive Treatment	Frequency (n=70)	Percentage (%)
Inotropes	70	100
Anti-epileptics	24	34.3
Anti edema measures (3 % saline)	23	32.8
Antibiotics	70	100
Anti-viral	5	7.1
Systemic steroids	26	37.1
Sedatives	60	85.7
Analgesics	24	34.3
Anti-snake venom	3	2.19

Final Outcome of the Study

Overall, majority of the participants survived (n=44, 62.9%) while 26 (n=26, 37.1%) participants expired in this study. (Table 16)

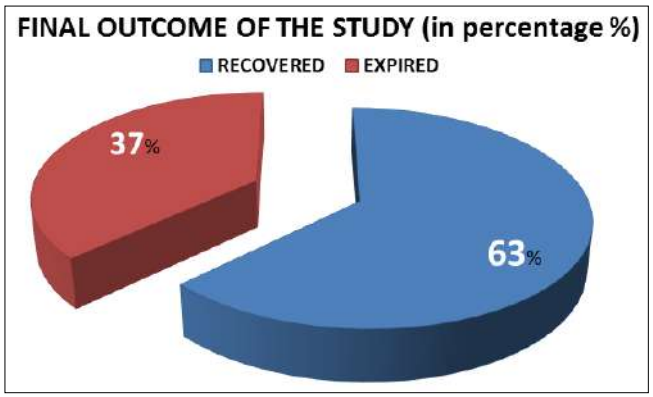

Fig 3: Final outcome of the study

Discussion

A total of 70 children required required mechanical ventilation during our study period of eighteen months.similar to the study by *Bhori NS et al*. [4] where in 72 children needed mechanical ventilation. Majority of the participants in our study were less than one year of age (n=35, 50%) followed by 1-5 years (n=30, 42.9%).

The predominant medical and social risk factors among the study participants who required mechanical ventilation were bottle feeding, past history of hospitalization and low socioeconomic status (n=32, 45.7%) . In contrast, in a study done by *Shirley GFA et al.* [3] the study participants belonging to low social economic status were slightly less.(n=70, 21.5%) The other common causes included poor sanitation (n=15, 21.4%) and overcrowding (n=13, 18.6%).

Fever was the most common symptom (n=45, 64.3%) among the study participants followed by difficulty in breathing (n=44, 62.9%), whereas in another study done by *Bhori NS et al.* [4] difficulty in breathing was the most common symptom (n=45, 62.5%) among the study participants followed by Fever (n=39, 54.17%). The predominant clinical sign observed among the study

participants was tachycardia (n=67, 95.7%) and tachypnoea (n= 52, 87.1%) followed by reduced levels of oxygen saturation (n=52, 74.3%). Not many studies are available which has taken into consideration, the clinical signs of the study participants.

Bronchopneumonia was highly prevalent among the study participants (n=20, 28.6%) followed by bronchiolitis (n=18, 25.7%). Similarly, in a study done by *Shirley GFA et al.* [3] bronchopneumonia was the predominant diagnosis (28.8%) and in a study done by *Bhori NS et al.* [4] respiratory causes were the most common causes for mechanical ventilation (62.5%) However, in the study done by *Dharmaraj S et al.* [5] central nervous system causes were the most common diagnosis (30.3%) followed by bronchopneumonia in 10.7%.

Overall severe respiratory distress was the most common indication for MV in the present study (32.9%) followed by respiratory failure (18.6%), whereas in the study done by *Shirley GFA et al.* [3] 51.4% of the participants had respiratory failure requiring mechanical ventilation, which is much higher than that of our study and in the study done by *Bhori NS et al.* [4] 20.8% of the participants were mechanically ventilated for respiratory failure.

The mean duration of mechanical ventilation in the present study was 3.4 days. In a study done by *Bhori NS et al.* [4] longer duration of ventilation was observed (5.16 days). Similarly in a study done *by Farias et al* [6] the mean duration of mechanical ventilation was 5 days. All these studies had a longer mean duration of ventilation than our study. In a study done by *Sahoo et al.* [7] the mean duration of mechanical ventilation was 5 days, which is lesser when compared to our study.

In the present study, the most prevalent complication was Ventilator Associated Pneumonia (VAP) in (n=21, 30%) of the participants. Similar findings were seen in study done by *Shirley GFA et al.* [3] (21.1%), *Srinivasan et al.* [8] (32%), *Tullu et al.* [9] (27.4 %). In the study done by *Kendirli et al* [10], VAP was seen in 17.5 %, which is lesser than our study. In the study done by *Bhori NS et al.* [4] laryngeal oedema resulting in obstruction of the endotracheal tube was the most common complication (11.11%) followed by VAP in 5.56%, which is much lesser than our study.

It was observed that total counts were elevated in 91.4% (n=64) of the participants, while C-reactive protein was elevated in 68.6% (n=48) of the participants. In another study done by *Virrki et al.* [11] total counts were elevated in 47 % (n = 102) and C-reactive protein was elevated in 28 % (n = 60), which were lesser when compared to our study. Not many studies are available which has taken into consideration, the laboratory profile of the study participants.

In our study, Ventilator associated pneumonia was seen in 30 % (n = 21) of the participants. In another study done by *Shriley GFA et al.* [3], Ventilator associated pneumonia was seen in 21 % (n = 4) of the participants. In another study done by *Awasthi S et al.* [12] the incidence of Ventilator associated pneumonia was 36.2 % (n = 38). The incidence of Ventilator associated pneumonia in a study done by *Srinivasan et al.* [8] was 32 %, which is a higher than our study.

The Endo tracheal tube cultures were positive for Multidrug resistant staphylococcus aureus (MRSA), Vancomycin Resistant Staphylococcus aureus (VRSA), Klebsiella and E. Coli. No growth was found in 51.4% of the participants. In a study by Awasthi S *et al.* [12] the most common pathogens were Klebsiella, Staphylococcus aureus and Candida. In a study by *Aelami et al.* [13] the most common pathogens were Pseudomonas aeroginosa and Acinetobacter. In a study done by *Balasubramanian P et al.* [14] the most common pathogen was Acinetobacter species, where as in a study by *Park et al.* [15] the common organism was Pseudomonas.

Chest X ray taken prior to the intubation showed that 25.7% (n=27) of the participants had hyperinflation and 17.1% (n=15) had pulmonary oedema and 38.6% (n=27) of the chest x rays were normal. However, in the subsequent X rays, 62.8% (n=44) of the X-rays were normal, while 37.1% (n=26) showed pneumonic infiltrates. In another study done by *Erdem et al.* [16], the most common chest x ray finding was consolidation (n = 135, 88.8 %) ,followed by interstitial infilterates (n = 40, 26.3 %). In another study done by *Prodhan, P et al.* [17] the most common chest x ray finding was hyperinflation (n = 19 ,76 %), followed by atelectasis (n = 13 , 52 %).

The common complications of the disease encountered among the study participants were refractory shock (n=31, 44.3%), septicaemia (n=22, 31.4%) and multi-organ dysfunction syndrome (n=22, 31.4%). In a Study by *Inwald DP et al.* [18], the common disease complication encountered was septic shock (17%), whereas in a study reported by Branco *et al.* [19] and *Sarthi et al.* [20] septic shock was encountered in more than 50 % of the participants. In a study done in an intensive care unit in Pakistan by *Khan MR et al.* [21] septic shock was encountered in 36.2% of the study participants.

While almost all the participants were treated with inotropes and antibiotics, anti-epileptics were required in 34.3% (n=24) of the participants. No other studies are available which has taken special consideration regarding the supportive treatment received by the study participants.

The final outcome of MV in the present study revealed a mortality rate of 37.1% (n = 26). In the study done by *Dharmaraj S et al.* [5] there was a higher mortality rate of 55.3% while similar mortality rates were seen in the study done by *Bhori NS et al.* [4] The factors which influenced the outcome of MV in the present study were presence of acidosis (metabolic or respiratory), secondary infections witnessed through endotracheal tube culture and respiratory failure, radiologically evidenced by infiltrates in the chest X-Ray. The observed differences were statistically significant ($p<0.05$). There are very few studies that have correlated the outcomes of MV with baseline characteristics.

Conclusion

We noticed that respiratory causes like bronchopneumonia and bronchiolitis were the common conditions requiring mechanical ventilation, when they presented with severe respiratory distress and respiratory failure. Majority of the children were less than 1 year of age with poor socio economic status and bottle feeding as the common risk factors. This stresses the importance of providing health education regarding exclusive breast feeding, immunization, good sanitation, adequate nutrition and avoiding bad child rearing practices.

Recognition of ventilator associated pneumonia in mechanically ventilated children is mandatory and must be earlier, since it is the most common complication.

A close monitoring of the vital signs and laboratory profile of the patients is of paramount importance in early

recognition of disease complications like refractory shock, multi organ dysfunction which carries grave prognosis.
More cohort studies are needed in future to estimate the long term sequelae and outcome in mechanically ventilated children.

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