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ORIGINAL ARTICLE

Evaluation of Clinical and Radiological Factors Determining the Need of Post-operative Ventilator Requirement in Patients of Esophageal Atresia

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ABSTRACT

Objective: Ventilator requirement is an important constituent of post-operative care of patients of esophageal atresia (EA). In contrast to the developed world, the situation is very different in developing countries where the resources are limited, and ventilator may not be available to all patients of EA. This study was conducted to assess whether there are certain criteria, which may predict the possibility of non- requirement of ventilator for patients of EA in the post-operative period. **Design:** This study was a retrospective observational study. **Setting**: This study was conducted at a tertiary care teaching hospital. **Duration**: This study was conducted for 5 years and 6 months. **Materials and Methods:** We used certain parameters to assess the requirement of ventilators for the patients in the post-operative period. These included the presentation of patients before or after 3 days of life and birth weight (BW) of more or <2.5 kg. Presence of respiratory distress (RD) was analyzed. The presence of consolidation on X-ray was also evaluated. **Results**: The total number of patients was 175. In univariate analysis, the need of ventilator was significantly higher in patients presenting after 3 days of life, weight <2.5 kg, presence of RD, and pneumatic patch. In multivariate analysis, the age of presentation, weight, RD, and consolidation were found to independent factor for the ventilator requirement. **Conclusion**: On the basis of clinical and radiological features, namely, age, sex, BW, RD, and consolidation, we may prioritize these patients of EA, who may not be requiring the ventilator in the post-operative period. Further prospective studies on the basis of these factors may substantiate our efforts.

Key words: Esophageal atresia; Post-operative period; Prognosis; Survival; Ventilator

INTRODUCTION

Esophageal atresia (EA) with or without tracheoesophageal fistula (EA±TEF) is a common congenital anomaly of the esophagus. In most centers of the developed world, the infant returns to the neonatal intensive care for ventilator support in the post-operative period [1]. The situation is very different in developing countries where the resources are limited. This is due to the fact that the number of ventilators is limited, and apart from neonates having surgical problems such as EA±TEF, the same ventilators may be needed for medical causes such as respiratory distress (RD) syndrome. Thus, there may be a need for recognizing the neonates of EA±TEF who may be operated upon without the need of ventilator in the post-operative period.

Various classification systems such as Waterston's, Spitz, and Montreal classification system, etc. have been proposed to predict the survival of neonates of EA±TEF. However, there is no study in which there is a possible prediction of requirement of ventilator in post-operative period for patients of EA±TEF.

This study was conducted to assess whether there are certain parameters, which may recognize the possibility of non-requirement of ventilator for patients of EA±TEF in the post-operative period.

MATERIALS AND METHODS

This was a retrospective observational study conducted in the Department of Pediatric Surgery of the Medical University. The duration of this study was

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from January 2011 to July 2016. All neonates of EA±TEF (Pure EA and type C of Ladd and Gross classification) were included in this study.

The diagnosis of EA±TEF was made on clinical and radiological basis. Resuscitation of the patients included oronasal suction, intravenous (IV) fluid, IV antibiotics, and O_2 supplementation by hood. All patients were evaluated for age, sex, and weight. We also assessed the oxygen saturation with or without oxygen support by pulse oximetry and respiratory rate (RR). Pre-operative X-ray (babygram) was obtained in all patients to assess the type of EA, level of upper esophageal pouch in relation to cervical vertebrae, and consolidation. It also helped to rule out other bony abnormalities.

After the surgery, those patients who could be safely extubated as evaluated by the anesthetist on duty were extubated. However, if extubation was not possible, the patient was shifted to a ventilator. The requirement of ventilator implied placing the neonate on ventilator for any period of time, for example, 30 min to few days. Based on the clinical evaluation, extubation was attempted as soon as possible. We used certain parameters to evaluate the requirement of ventilators for the patients in the post-operative period. These included the presentation of patients before or after 3 days of life and birth weight (BW) of more or <2.5 kg. The presence of RD was analyzed. RD was said to be present if RR was more than 60/min. O_2 saturation was evaluated with or without supplementation. It was said to be less than normal if it was <90% on pulse oximetry with O_2 support. The presence of consolidation on X-ray was also evaluated. It was said to be significant if it involved one or more than one lobe of lung.

Pre-operative echocardiography or ultrasonography of abdomen was not performed in our setup.

The patients were operated by standard right thoracotomy through a extrapleural approach. The patients were operated when the RR was below 60/min; O_2 saturation was ≥95% on pulse oximetry.

All the data were entered into the Microsoft Excel sheet. The results were analyzed using IBM SPSS Statistics for Windows, Version 16.0. (SPSS Inc., Chicago IL, USA). The results are presented in mean±standard deviation, frequency, and percentages. Chi-square test was used to compare categorical/dichotomous variables. The relative risk with 95% confidence interval (CI) was calculated to find the strength of association. The univariate and multivariate logistic regression was used to find the factors associated with ventilator requirement. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of the model were calculated. The $P < 0.05$ was considered statistically significant.

RESULTS

The duration of this study was 5½ years. The total number of patients (n) was 175. Out of 175 patients, 13 patients left hospital against medical advice. Rest 162 patients were analyzed. Male-to-female ratio was 2.86:1. The mean age of presentation was 4.81 ± 4.08 days. The mean weight was 2.43 ± 0.45 Kg. Type C was present in 145 (89.5%) and Type A was seen in 17 (10.5%) patients. RD was seen in 71 (43.8%) patients. Consolidation was observed in 64 (39.5%) patients. The patients who presented within 3 days of life were 72 (44.4%), and remaining 90 (55.6%) patients presented after 3 days of age. The patients having weight of more than 2.5 kg were 54 (33.3%).

RD was significantly higher in babies who presented after 3 days of life as compared to babies presenting before 3 days of life ($P < 0.05$). Presence of consolidation was significantly higher in babies who presented after 3 days of life as compared to babies presenting before 3 days of life ($P < 0.05$). Both RD and consolidation were significantly higher in babies who presented after 3 days of life as compared to babies presenting before 3 days of life ($P < 0.05$, Table 1).

In univariate analysis, the need of ventilator was significantly higher in patients presenting after 3 days of life as compared to one presenting before 3 days of life (RR = 0.02, 95% CI = 0.01–0.16, $P = 0.0001$). The need of ventilator was significantly higher in patients with low weight at the time of presentation (<2.5 kg) as compared to one having >2.5 kg weight at the time of presentation (RR = 1.83, 95% CI = 1.05–3.17, $P = 0.01$). Ventilator requirement was significantly higher in patients with RD as compared to patients having no RD (RR = 6.69, 95% CI = 3.52–12.72, $P = 0.0001$). Patients having consolidation had significantly increased need for ventilator support as compared to patients having no PP on X-ray chest (RR = 9.18, 95% CI = 4.65–18.11, $P = 0.0001$). In patients with RD and consolidation, the requirement of ventilator was significantly more as compared to patients having no RD and consolidation (RR = 6.91, 95% CI = 4.35-10.99, $P = 0.0001$). The expiry was significantly higher in patients on ventilator support (RR = 1.68, 95% CI = 1.11–2.54, $P = 0.01$, Table 2).

In multivariate analysis, the age of presentation, weight, RD, and consolidation were found to independent factor for the ventilator requirement (Table 3). On analyzing the patients based on the age of presentation of more than 3 days of life, weight at presentation <2.5 kg with clinical present RD, and consolidation on chest X-ray, the statistical values obtained revealed increased requirement of ventilator support in post-operative period (specificity - 86.8, sensitivity - 96.4, PPV - 79.4, and NPV - 97.9) with accuracy of 90.1%).

Table 1: Clinical and radiological factors in patients of esophageal atresia in relation to the age at presentation

Parameters	Age in days		*P* value[1]
	<3 *n*=72	≥3 *n*=90	
	No. (%)	No. (%)	
Respiratory distress			
Present	17 (23.9)	54 (76.1)	0.0001*
Absent	55.9 (60.4)	36 (39.6)	
Consolidation			
Present	1 (1.6)	63 (98.4)	0.0001*
Absent	71 (72.4)	27 (27.6)	
Respiratory distress + consolidation			
Present	1 (2.3)	42 (97.7)	0.0001*
Absent	71 (59.7)	48 (40.3)	
Gender			
Male	53 (44.2)	67 (55.8)	0.90
Female	19 (45.2)	23 (54.8)	

The percentage of respiratory stress, consolidation, and both were significantly (*P*=0.0001) higher in children who presented late. There was no significant (*P*>0.05) between gender and age of presentation. [1]Chi-square test, *significant

DISCUSSION

Ventilator support is an important requirement in post-operative period for EA±TEF [2,3]. At our center, the requirement of ventilator overwhelms its supply. This is due to the fact that same ventilator are used by neonates having some other medical as well as surgical causes. For this reason, we felt the need for trying to predict the factors, which, if present, may be helpful for non-requirement of ventilator in post-operative period. Before conducting this study, we believed that female patient had better survival, which was not found in this study. The time duration for ventilator requirement was non-specific, as for any period of time, there was a need to shift the patient to the ventilator unit.

Male-to-female ratio was 2.86:1 in this study, which is in accordance with other studies from developing countries [4-6]. Most of the patients who left treatment against medical advice were female. This is probably due to more attention paid toward male children in this part of the world. According to one study from India, only 10% patients diagnosed to be having EA TEF, reach a tertiary care center [4]. This delay occurs due to delayed diagnosis – both antenatal and postnatal, poor diagnostic facilities in the countryside, and poor transportation facilities. Many tertiary care centers situated in metropolitan cities are overburdened. That is in contrast to the Western world with respect to both manpower and machinery [7].

In an observational study, it was observed that age at the time of admission is not a bad prognostic factor; however, others have noticed that delayed presentation points toward poor prognosis [8-10]. In our study, we also found this to be significantly associated with overall survival. In one study from Asia, BW <2.5 kg was considered to be a high-risk factor and babies with BW <1.8 kg had the lowest survival rate. BW has been among one of the important prognostic factors in survival of patients of EA±TEF [10]; however, sporadic studies did not find the same to be true [11].

For survival of patients of EA±TEF, various prognostic criteria have been proposed and accepted over time. These include Waterston, Montreal, and Spitz classification [12-17]. According to Waterston, the risk factors to be considered are BW, the presence or absence of pneumonia, and complications from associated congenital anomalies. Spitz et al. proposed a new and simpler system based on associated congenital heart defects and low BW status for the modern era. Montreal differs by based on two independent variables – preoperative ventilator dependence and associated major anomalies. At present, in most of the developed countries, only the presence of associated major congenital anomalies determines the chances of survival. This is not the situation in developing countries, where many pre-operative, post-operative, and socioeconomic factors, as discussed above, may contribute to the increased mortality.

There has been no specific study, which has specifically looked for the need of ventilator in post-operative in patients of EA±TEF. This may not be required in the developed world where facilities are adequate; however, as mentioned above, this becomes important if there is a mismatch in demand and supply like in our setup.

We noticed that ventilator requirement was statistically less in patients of age <3 days. As mentioned earlier, early age of presentation is a good prognostic sign. Hence, this appears to be a reasonable outcome. Likewise, the weight of more than 2.5 kg was associated with less requirement of ventilator. Weight of more than 2.5 kg has been recognized as a good prognostic factor for survival of patients.

Table 2: Association of clinical and radiological factors with ventilator requirement in post-operative period

Parameters	Number of patients	Ventilator		RR (95% CI), ***P*** value[1]
		Yes	No	
		No. (%)	No. (%)	
Age in days				
<3	72	1 (1.4)	71 (98.6)	0.02 (0.01–0.16), 0.0001*
≥3	90	55 (61.1)	35 (38.9)	1.00 (Ref.)
Gender				
Male	120	43 (35.8)	77 (64.2)	1.15 (0.69–1.93), 0.56
Female	42	13 (31.0	29 (69.0)	1.00 (Ref.)
Birth weight in kg				
≤2.50	108	44 (40.7)	64 (59.3)	1.83 (1.05–3.17), 0.01*
>2.50	54	12 (22.2)	42 (77.8)	1.00 (Ref.)
RD				
Present	71	47 (66.2)	24 (33.8)	6.69 (3.52–12.72), 0.0001*
Absent	91	9 (9.9)	82 (90.1)	1.00 (Ref.)
PP				
Present	64	48 (75.0)	16 (25.0)	9.18 (4.65–18.11), 0.0001*
Absent	98	8 (8.2)	90 (91.8)	1.00 (Ref.)
PP+RD				
Present	43	40 (93.0)	3 (7.0)	6.91 (4.35–10.99), 0.0001*
Absent	119	16 (13.4)	103 (86.6)	1.00 (Ref.)
Outcome				
Expired	55	26 (47.3)	29 (52.7)	1.68 (1.11–2.54), 0.01*
Survived	107	30 (28.0)	77 (72.0)	1.00 (Ref.)

[1]Chi-square test, RR-Relative risk, CI-Confidence interval, Ref.-Reference, *Significant, RD: Respiratory distress, PP: Pneumatic patch. In the univariate analysis, the need of ventilator was significantly higher who presented late. The need of ventilator was 98% lower in the age <3 days than ≥3 (RR=0.02, 95% CI=0.01–0.16, *P*=0.0001). Low birth weight accounted for 40.7% ventilator need. The ventilator need was 1.83 times significantly higher in low weight compared to normal weight (RR=1.83, 95% CI=1.05–3.17, *P*=0.01). RD, PP and both, were significantly (*P*=0.0001) associated with the need of ventilator. The expiry was significantly (*P*=0.01) higher who was on ventilator

RR of more than 60/min indicates RD. This may be due to aspiration of saliva from upper pouch or gastric juice reflux through fistula. This may account for poor prognosis; hence, pre-operative management of RD is important. Settling of RR to <60 indicates a response to treatment and possibility of less requirement of ventilator. This aspiration manifests as aspiration pneumonitis, which is documented as consolidation of chest X-ray. More aspiration or delayed presentation may lead to increased pneumonitis, which may manifest as the involvement of more than one lobe of lung. Thus, it is evident that

Table 3: Factors associated with requirement of ventilator in post-operative period-Multivariate logistic regression analysis

Factors	Adjusted OR	95.0% CI adjusted OR		*P* value
		Lower	Upper	
Age in days				
<3	0.02	0.003	0.26	0.002*
≥3	1.00 (Ref.)			
Weight in kg				
≤2.50	3.78	0.98	14.58	0.05**
>2.50	1.00 (Ref.)			
RD				
Present	23.76	6.25	90.29	0.0001*
Absent	1.00 (Ref.)			
PP				
Present	15.23	3.68	63.02	0.0001*
Absent	1.00 (Ref.)			

OR: Odds ratio, CI: Confidence interval, Ref.: Reference, *Significant, **Nearly significant. The multivariate analysis showed that age of presentation, weight, RD and PP were found to independent factor for the ventilator requirement (Table 3)

these factors are interrelated. Taking care of RD and pneumonitis in pre-operative period or their absence may lead to decreased ventilator requirement in the post-operative period.

As mentioned in the results, our observations were validated on univariate analysis. Besides, in multivariate analysis, the age of presentation, weight, RD, and consolidation were found to independent factor for the ventilator requirement.

The limitation of this study is its retrospective nature. However, we feel that before identifying the responsible factors, it would have been unethical to test them in a prospective one. We have not assessed the coexisting congenital anomalies, especially, heart anomalies. It was due to the fact that the facilities to diagnose it were not available in the vicinity, and patient transportation would have been risky. It is also to be noticed that Nasr et al. [18] demonstrated that normal clinical and radiologic examination predicts the absence of significant cardiac abnormalities on echocardiography in 100% of cases. Therefore, these authors conclude that routine pre-surgical echocardiography may not always be necessary but should be reserved for infants with abnormal clinical and/or radiologic findings. However, we do agree that survival is affected by the co-existing anomalies. Since we tried to evaluate the clinic-radiologic parameters, which may be important for requirement of ventilator in the post-operative period, it was not the study protocol to evaluate pre-operative ventilator requirement. Likewise, repeat ventilator requirement after weaning for iatrogenic causes such as leak was not studied. We feel that evaluating too many factors in a single study would have complicated it.

The survival in this study was 65%. In India, the survival rate has been between 60% and 80% [19]. Survival may be affected by coexisting anomalies [20].

To conclude, on the basis of certain clinical and radiological features, namely age, sex, BW, RD, and consolidation, we may recognize those patients of EA±TEF, who may not be requiring the ventilator in the post-operative period. Further prospective studies on the basis of these factors may substantiate our efforts.

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