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Original Research Article

Association of Prolonged AMV with Fluid Balance and Pediatric Index of Mortality 2 (PIM2) Score in Children Admitted to Pediatric Intensive Care Unit (PICU)

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Abstract

Aim: This study was conducted to determine the association of prolonged AMV with fluid balance and pediatric index of mortality 2 (PIM2) score.

Methods: This prospective observational study was conducted over a period of 12 months in the pediatric intensive care unit (PICU) at SKMCH, Muzaffarpur, Bihar, India. The study enrolled all patients admitted in the PICU of age 29 days to 12 years, who fulfill the inclusion criteria during the 12-month period.

Results: This was a study of 50 participants of which infants (<1 year) were maximum (26, i.e., 52%). Males outnumbered females comprising 58% (29) of the study population. Maximum number of admissions (16) had central nervous system involvement followed by respiratory system involvement. Out of the 50 children admitted in PICU during the study period, 35 (70%) children had prolonged mechanical ventilation. 33 patients had positive fluid balance ≥ 15%. 30 patients who had ≥15% positive fluid balance required prolonged mechanical ventilation. Similarly, 30 patients who had PIM2 score ≥ 5 required prolonged mechanical ventilation. The Pearson chi-square test was applied to test the significance of association between positive fluid balance and prolonged mechanical ventilation. P value was $2:25 \times 10^{-7}$ which is <0.05 suggesting rejection of null hypothesis and statistically significant association between two variants.

Conclusion: There was a significant association of prolonged AMV with positive fluid balance (>15%) and PIM2 score (>5). By strict maintenance of fluid balance with appropriate intervention, the length of AMV and PICU stay can be decreased.

Keywords: fluid Balance, Mechanical Ventilation, Children, Pediatric Intensive Care Units.

Introduction

Fluid balance is one of the most challenging aspects of critically-ill children requiring pediatric intensive care. While early and aggressive fluid resuscitation is lifesaving and widely practiced, excess fluid may be detrimental. Mechanically ventilated children may be more prone to fluid overload as they have lesser evaporative losses due to warmed, humidified gases and thermocontrolled environment. [1] Presence of non-osmotic stimuli, in addition to osmotic stimuli, for anti-diuretic hormone (ADH) release may contribute to fluid retention. [2,3] In addition, overestimation of fluid requirement occurs if traditional methods designed primarily for healthy children are used. [4] The Fluids and Catheters Treatment Trial (FACTT) in adults concluded that, patients managed with fluid restriction had lesser duration of intensive care unit stay and mechanical ventilation than patients who received liberal fluids. [5] The observations from few retrospective studies in children suggest adverse effects of positive fluid balance on respiratory morbidity and mortality. [6]

Mechanical ventilation is a crucial component of intensive care unit (ICU) that helps in supporting and sustaining life of critically ill patients. Ventilator-associated lung injury (VALI) is an inevitable consequence of assisted mechanical ventilation (AMV) [7,8], and to curtail the same in acute respiratory distress syndrome (ARDS), lung protective ventilation strategies have been developed, which has led to significant reduction in death rates. [9-11] Assisted mechanical ventilation

(AMV) is a frequently used life support system which, in spite of its benefit, might cause damage. Unwanted consequences arising from the use of AMV are generically known as ventilator-associated lung injury, [12] and were the reason for lung protective ventilation strategies which resulted in a significant mortality reduction among patients with acute respiratory distress syndrome. [13,14]

After gathering data corresponding to initial 48 hours of AMV, this study is trying to exhibit the association between fluid balance and prolonged mechanical ventilation if any and generalizing the same to wider population range and, similarly, to study the association of prolonged mechanical ventilation with other variables such as pediatric index of mortality 2 (PIM2) score, hypoxic respiratory failure, cardiovascular failure, age and gender. [15,16]

This study was conducted to determine the association of prolonged AMV with fluid balance and pediatric index of mortality 2 (PIM2) score.

Materials and Methods

This prospective observational study was conducted over a period of 12 months in the pediatric intensive care unit (PICU) at SKMCH, Muzaffarpur, Bihar, India. The study enrolled all patients admitted in the PICU of age 29 days to 12 years, who fulfill the inclusion criteria during the 12-month period from the initiation of the study excluding those children previously admitted in the PICU of any other hospital and referred from those hospitals. Study participants were enrolled for a period of 7 days.

At the time of admission, the patients' clinical profile was recorded in a prefixed case record form consisting of age, sex, date of admission, provisional clinical diagnosis, PIM2 score, and organ system primarily involved. Information regarding results of blood investigations like arterial blood gas parameters (PaO2, base excess, FiO2) was collected from the hospital records. Recordings of total fluid given and total fluid output in the first 48 hours of mechanical ventilation were documented. Fluid balance was calculated by the difference between the total amount of fluid administered and the sum of all the losses experienced during the first 48 hours of AMV by using the formula ðfluid input − fluid output/weight × 100. [17,18] PIM2 score was calculated by tabulating the following information such as (1) whether the admission was emergency/elective (in case of surgeries), (2) any underlying premorbid conditions (cardiac arrest out of hospital, severe combined immune deficiency, leukaemia/lymphoma after the first induction, spontaneous cerebral haemorrhage from aneurysm or AV malformation, cardiomyopathy, myocarditis, hypoplastic left heart syndrome, HIV infection, and neurodegenerative disorder), (3) response of pupils to light, (4) mechanical ventilation at any time during the first hour in PICU, (5) systolic blood pressure, (6) base excess, and (7) FiO2/PaO2 ratio. [19] The associated factors for mortality were scrutinized with SPSS 17. PIM2 score was used as a tool to distinguish death and survival at a 99.8 cutoff with 95% confidence interval (CI).

PaO2/FiO2 ratio was measured, and if found <200 in the absence of cyanotic heart disease or left ventricular dysfunction, diagnosis of hypoxic respiratory failure was made. [20] Individual patients were evaluated for the presence of cardiovascular failure which is defined as arterial hypotension (<5th percentile for the age) or the need to use vasoactive drugs (dopamine, epinephrine, and norepinephrine at any dose). [21,22] Duration of mechanical ventilation, duration of PICU stay, and outcome were recorded subsequently and analysed with precision.

Statistical Analysis

The recorded data was compiled and entered in a spreadsheet computer program (Microsoft Excel 2010) and then exported to data editor page of SPSS version 20 (SPSS Inc., Chicago, Illinois, USA).

Descriptive statistics included computation of percentages, means and standard deviations were calculated. Statistical test applied for the analysis was independent sample t-test. The level of confidence interval and p-value were set at 95% and 5%.

Results

Table 1: Association among the cases between duration of mechanical ventilation ≥ 7 days and fluid balance (≥15%)

Duration of mechanical ventilation ≥7 days	Fluid balance (≥15%)		Total
	Yes	No	
Yes	30	5	35 (70)
No	3	12	15 (20)
Total	33	17	50 (100)

This was a study of 50 participants of which infants (<1 year) were maximum (26, i.e., 52%). Males outnumbered females comprising 58% (29) of the study population. Maximum number of admissions (16) had central nervous system involvement followed by respiratory system involvement. Out of the 50 children admitted in PICU during the study period, 35 (70%) children had prolonged mechanical ventilation. 33 patients had positive fluid balance ≥ 15%. 30 patients who had ≥15% positive fluid balance required prolonged mechanical ventilation.

Table 2: Significance of association between positive fluid balance and prolonged mechanical ventilation and Significance of association between PIM2 score and prolonged ventilation

Significance of association between positive fluid balance and prolonged mechanical ventilation				
Chi-square test	Value	Df	P value	Association
Pearson chi-square test	26.804	1	2:25 × 10−7	Significant
Continuity correction	22.953	1	1:66 × 10−6	Significant
Fisher's exact test			8:05 × 10−7	Significant
Significance of association between PIM2 score and prolonged ventilation				
Chi-square test	Value	Df	P value	Association
Pearson chi-square test	19.177	1	1:19 × 10−5	Significant
Continuity correction	15.730	1	7:31 × 10−5	Significant
Fisher's exact test			5:15 × 10−5	Significant

Similarly, 30 patients who had PIM2 score ≥ 5 required prolonged mechanical ventilation. The Pearson chi-square test was applied to test the significance of association between positive fluid balance and prolonged mechanical ventilation. P value was 2:25 × 10−7 which is <0.05 suggesting rejection of null hypothesis and statistically significant association between two variants. Similarly, on applying the Pearson chi-square test to find out the association between PIM2 score and prolonged ventilation, observed P value was 1:19 × 10−5 (<0.05) suggesting statistically significant association. However, association of other variables with prolonged mechanical ventilation was not statistically significant. The mean duration of PICU stay was prolonged in patients who required prolonged mechanical ventilation.

Table 3: Correlation between duration of mechanical ventilation (days) and various other variables

Variables	**Pearson correlation**	**Duration of mechanical ventilation**	**Age (yrs.)**	**Duration of PICU stay (days)**	**Fluid balance (%)**	**PIM2 score**
Duration of mechanical ventilation (days)	Pearson's r	1.000	-0.224	0.925	0.297	0.034
	P value		0.165	0.01	0.063	0.833
Age (yrs.)	Pearson's r	-0.224	1.000	-0.175	-0.302	-0.031
	P value	0.165		0.280	0.059	0.852
Duration of PICU stay (days)	Pearson's r	0.925	-0.175	1.000	0.168	0.027
	P value	0.01	0.280		0.299	0.869
Fluid balance (%)	Pearson's r	0.297	-0.302	0.168	1.000	0.176
	P value	0.063	0.059	0.299		0.278
PIM2 score	Pearson's r	0.034	-0.031	0.027	0.176	1.000
	P value	0.833	0.852	0.869	0.278	

Correlation was found between duration of mechanical ventilation ≥ 7 days and fluid balance, PIM2 score ≥ 5, and duration of PICU stay with Pearson's r value 0.297, 0.034, and 0.925, respectively.

Discussion

Mechanical ventilation may be necessary for a child referred to the paediatric intensive care unit (PICU) for one or more causes, for a short or long time depending on the ventilation rationale and several other factors that either directly or indirectly contribute to the illness process. AMV is a commonly used form of life support that, despite its advantages, might be harmful if the right guidelines are not followed. Fluid balance, the PELOD (paediatric logistic organ dysfunction) score, the PIM2 score at admission, underlying comorbidities, and cardiovascular and respiratory failure at admission are only a few of the critical variables that affect the length of breathing. [7,8]

70.0% (35) of all patients admitted to our PICU required extended mechanical ventilation. Similar findings were found in research conducted at a tertiary referral university teaching hospital in southern Thailand by Khwannimit and Koonrangsesomboon [23], which had a 72.8% (763/1048) success rate. In the Vidal et al. [7] study, 50.3% of patients (82/163) in a retrospective cohort in the PICU of Hospital Italiano de Buenos Aires had extended mechanical breathing.

33 patients in this study had positive fluid balance of ≥15% and 35 patients (70%) had prolonged mechanical ventilation. 33 patients who had ≥15% positive fluid balance required prolonged mechanical ventilation. The Pearson chi-square test was applied to test the significance of association between positive fluid balance and prolonged mechanical ventilation. P value was 2:25 × 10−7 (<0.05) suggesting rejection of null hypothesis and statistical significance. In a study by Vidal et al. [7] on fluid balance and length of mechanical ventilation in children admitted to a single PICU, during the study period, 1655 patients were admitted; 249 remained on AMV for over 48 hours and 163 were included in the study. The univariate analysis showed that the age younger than 4 years old (OR 3.21, 95% CI: 1.38-7.48), respiratory disease (OR 4.94, 95% CI: 1.51-16.10), septic shock (OR 4.66, 95% CI: 1.10-19.65), PELOD > 10 (OR 2.44, 95% CI: 1.23-4.85), and positive balance > 13% of the body weight (OR 4.02, 95% CI: 1.08-15.02) were associated with prolonged mechanical ventilation.

In a study from a South African PICU by Ketharanathan et al. [24], one hundred consecutive PICU admissions were included; before PICU admission, 59 children received a median 8.0 (4.0–15.0) ml/kg of fluid bolus. During PICU admission, 40 patients received a median fluid bolus amount of 10.0 (3.0–27.5) ml/kg. A total of three patients had a fluid overload ðFOÞ% ≥ 10, even after correction for convalescent weight. The median minimum and maximum amount of maintenance fluid during PICU admission was 60 (46.0– 80.0) ml/kg/day and 100.0 (60.0–120.0) ml/kg/day, respectively. The PICU mortality was 8%, and 28-day mortality was 10%.

In a study by van Mourik et al. [25], 600 ARDS patients were studied to know the predictability of fluid balance with 28-day and 90-day mortality along with length of ICU stay. 156 patients (26%) died within 28 days. Patients with a higher cumulative fluid balance on day 7 had a longer length of ICU stay and fewer ventilator-free days on day 28. Similar results were found for 90-day mortality. A more positive fluid balance predicted mortality, and a negative fluid balance showed a trend towards survival. Confounding factors that alter fluid balance such as hemodialysis and diuretic use have been considered separately. However, in our study, none of the patient required hemodialysis or diuretics.

Conclusion

The study has demonstrated significant associations of fluid balance ≥ 15% and PIM2 score ≥ 5 with prolonged duration of mechanical ventilation. Patients who had positive fluid balance ≥ 15% had more chances of prolonged mechanical ventilation in comparison to those who had PIM2 score ≥ 5, indicating more significant association of positive fluid balance with duration of mechanical ventilation. We found less significant association with hepatobiliary and renal involvement; however, because of small sample size it cannot be applied to the general population. To establish a clear-cut association with organ system involvement and to strengthen the significance of association, further prospective studies are required with a large sample size.

References

1. Duke T, Molyneux EM. Intravenous fluids for seriously ill children: time to reconsider. The Lancet. 2003 Oct 18;362(9392):1320-3.
2. Schrier RW, Berl T, Anderson RJ. Osmotic and nonosmotic control of vasopressin release. American Journal of Physiology-Renal Physiology. 1979 Apr 1;236(4):F321-32.
3. Schrier RW, Goldberg JP. The physiology of vasopressin release and the pathogenesis of impaired water excretion in adrenal, thyroid, and edematous disorders. The Yale Journal of Biology and Medicine. 1980 Nov;53(6):525.
4. Briassoulis G, Venkataraman S, Thompson A. Nutritional-metabolic factors affecting nitrogen balance and substrate utilization in the critically ill. Journal of Pediatric Intensive Care. 2012 Jun;1(02):077-86.
5. Wiedemann HP. A perspective on the fluids and catheters treatment trial (FACTT). Fluid restriction is superior in acute lung injury and ARDS. Cleveland Clinic journal of medicine. 2008 Jan 1;75(1):42-8.
6. Valentine SL, Sapru A, Higgerson RA, Spinella PC, Flori HR, Graham DA, Brett M, Convery M, Christie LM, Karamessinis L, Randolph AG. Fluid balance in critically ill children with acute lung injury. Critical care medicine. 2012 Oct;40(10):2883.
7. Vidal S, Perez A, Eulmesekian P. Fluid balance and length of mechanical ventilation in children admitted to a single Pediatric Intensive Care Unit. Arch Argent Pediatr. 2016 Aug 1;114(4):313-8.
8. Slutsky AS, Ranieri VM. Ventilator-induced lung injury. The New England journal of medicine. 2014 Mar 1;370(10):980-.
9. De Luca D, Piastra M, Chidini G, Tissieres P, Calderini E, Essouri S, Medina Villanueva A, Vivanco Allende A, Pons-Odena M, Perez-Baena L, Hermon M. The use of the Berlin definition for acute respiratory distress syndrome during infancy and early childhood: multicenter evaluation and expert consensus.

Intensive care medicine. 2013 Dec; 39:2083-91.
10. L. Camporota and N. Hart, "Lung protective ventilation," BMJ, vol. 344, no. apr05 2, pp. 2491–2497, 2012.
11. Neto AS, Cardoso SO, Manetta JA, Pereira VG, Espósito DC, Pasqualucci MD, Damasceno MC, Schultz MJ. Association between use of lung-protective ventilation with lower tidal volumes and clinical outcomes among patients without acute respiratory distress syndrome: a meta-analysis. Jama. 2012 Oct 24;308(16):1651-9.
12. Slutsky AS, Ranieri VM. Ventilator-induced lung injury. N Engl J Med 2013;369(22):2126-36.
13. The Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. N Engl J Med 2000;342 (18):1301-8.
14. Amato MB, Barbas CS, Medeiros DM, Magaldi RB, et al. Effect of a protective-ventilation strategy on mortality in the acute respiratory distress syndrome. N Engl J Med 1998;338(6):347-54.
15. Levy B, Perez P, Perny J, Thivilier C, Gerard A. Comparison of norepinephrine-dobutamine to epinephrine for hemodynamics, lactate metabolism, and organ function variables in cardiogenic shock. A prospective, randomized pilot study. Critical care medicine. 2011 Mar 1;39(3):450-5.
16. Vincent JL, De Backer D, Wiedermann CJ. Fluid management in sepsis: The potential beneficial effects of albumin. Journal of critical care. 2016 Oct 1; 35:161-7.
17. Arikan AA, Zappitelli M, Goldstein SL, Naipaul A, Jefferson LS, Loftis LL. Fluid overload is associated with impaired oxygenation and morbidity in critically ill children. Pediatric critical care medicine. 2012 May 1;13(3):253-8.
18. Hannon MJ, Finucane FM, Sherlock M, Agha A, Thompson CJ. Disorders of water homeostasis in neurosurgical patients. The Journal of Clinical Endocrinology. 2012 Feb 2297(5):1423-33.
19. Eulmesekian PG, Pérez A, Minces PG, Ferrero H. Validation of pediatric index of mortality 2 (PIM2) in a single pediatric intensive care unit of Argentina. Pediatric Critical Care Medicine. 2007 Jan 1;8(1):54-7.
20. A. Ghuman, C. Newth, and R. Khemani, "The association between the end tidal alveolar dead space fraction and mortality in pediatric acute hypoxemic respiratory failure," Pediatric Critical Care Medicine, vol. 13, no. 1, pp. 11–15, 2012.
21. Acheampong A, Vincent JL. A positive fluid balance is an independent prognostic factor in patients with sepsis. Critical care. 2015 Dec ;19(1):1-7.
22. Polito A, Patorno E, Costello JM, Salvin JW, Emani SM, Rajagopal S, Laussen PC, Thiagarajan RR. Perioperative factors associated with prolonged mechanical ventilation after complex congenital heart surgery. Pediatric Critical Care Medicine. 2011 May 1;12(3):e122-6.
23. Koonrangsesomboon W, Khwannimit B. Impact of positive fluid balance on mortality and length of stay in septic shock patients. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2015 Dec;19(12): 708.
24. Ketharanathan N, McCulloch M, Wilson C, Rossouw B, Salie S, Ahrens J, Morrow BM, Argent AC. Fluid overload in a South African pediatric intensive care unit. Journal of tropical pediatrics. 2014 Dec 1;60(6):428-33.
25. van Mourik N, Metske HA, Hofstra JJ, Binnekade JM, Geerts BF, Schultz MJ, Vlaar AP. Cumulative fluid balance predicts mortality and increases time on mechanical ventilation in ARDS patients: an observational cohort study. PloS one. 2019 Oct 30;14(10): e0224563.