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Quality improvement project for the prevention of VAP using bundle care approach in tertiary care hospital

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Abstract: Background and Aims: Ventilator associated pneumonia (VAP) develops after more than 48 hours of mechanical ventilation. VAP is the leading cause of death among hospital acquired infection and prolongs time spent on the ventilator, length of intensive care unit (ICU) stay and length of hospital stay after discharge from the ICU. The concept of 'bundles' which can be defined as groups of evidence based interventions when, performed together, improve outcome. Hence this study was undertaken to assess the incidence of VAP and effectiveness of Bundle to prevent VAP.
Methods: This study was conducted in two phases. Pre-interventional phase (Phase-1) is done for three months by observing the current practices in mechanically ventilated patents and assessing the incidence of VAP. Then in post-interventional phase is conducted for three months by applying the bundle care approach, educating the interns, staff nurses and contact care givers regarding the quality improvement project and then assessing the incidence of VAP.
Results: Total 40 patients were involved in the study with 20 patients in each trial. The incidence of VAP was more in pre-interventional trial and the VAP incidence was reduced in post-interventional trial after implementing bundle care.
Conclusions: VAP prevention can be achieved to a large extent with the use of Bundle care approach .However, a major limitation is the lack of adherence to the set protocols by the health care professional especially in developing countries like India where the still the Patient to Nurse ratio is poor and overworked doctors . But one of the way to improve is by educating them through targeted training and using checklist which will help to improve adherence and ultimately patient outcome.

Keywords: Ventilator associated pneumonia; Bundle care; DVT prophylaxis; Weaning; Sedation.

1. Introduction

Ventilator-associated pneumonia (VAP) is a type of hospital-acquired pneumonia (HAP) that develops after more than 48 hours of mechanical ventilation [1]. VAP is the leading cause of death among hospital acquired infection and prolongs time spent on the ventilator, length of intensive care unit(ICU) stay and length of hospital stay after discharge from the ICU.

According to international nosocomial infection control consortium (INCC) data VAP has an estimated incidence of 13.6/1000 mechanical ventilation (MV) days [2] . The VAP incidence is much higher in Asian countries and ranges from 3.5 to 46/1000 MV days [3]. The mortality rate in a patient who developed VAP ranges from 30 to 70% [1]. Considering the high mortality and high cost, in 2006 the Institute of Health care Improvement (IHI) adopted evidence- based interventions in intensive care [4]. IHI developed the concept of 'bundles' which can be defined as groups of evidence-based interventions when, performed together, improve outcome [4]. The ventilator bundle consists of evidence-based guidelines aiming to prevent VAP.

This study is the first step in a quality improvement initiative to improve care delivered to mechanically ventilated patients in order to reduce VAP rates at Hassan Institute of Medical science. Based on feasibility in our hospital and evidence, we selected VAP prevention bundle with 4 components which includes,

- Elevation of the Head of the bead (HOB),
- Daily sedation breaks,

- Weaning protocol (checking for readiness for spontaneous trial and extubation),
- DVT prophylaxis along with general infection control measure like Hand wash, use of glove etc.

The main purpose of this project is first to observe the current practices of VAP bundle in our ICU along with VAP incidence over first 3 month and the effect VAP Bundle which implemented by Interactive mass lectures, bedside trainings, one to one communication on VAP incidence over next 3 month.

2. Aims and objectives:

- To evaluate the Incidence rate of VAP before and after implementation of bundle care.
- To correlate the Incidence of VAP with bundle care approach.

3. Methodology:

3.1. Study design:

- Quasi Experimental Study

3.2. Study settings

- Conducted in MICU Hassan Institute of medical science for a period of 6month in 2 phases (January 2022 to June 2022),
- All the patient who are admitted in MICU and Mechanically Ventilated during the study period and meeting the inclusion and exclusion criteria are surveyed for VAP using CDC (2015), criteria and demographic, clinical , laboratory and radiological data are collected.
- Phase 1(pre intervention phase): 3 month, 20 patients
  - It is to observe the current practice of VAP bundle in our hospital
  - Data related to compliance of VAP bundle are collected daily with help of proforma (physician ticks the chart while doing rounds).
  - At the end of 3 month VAP incidence and compliance rate are calculated.
- Phase 2 (intervention phase): 3 months, 20 patient
  - Target groups : Residents, Nursing Staff, Treating Faculties
  - Intervention: Interactive mass lectures, bed side trainings, one to one communication and education posters, feedback session every month.
  - VAP incidence and compliance to the bundle care approach is calculated and correlate before and after the intervention.
- VAP Bundle components
  - Head elevation>30-45degrees
  - Optimize sedation(RASS 0 to -1)
  - Weaning protocol(checking for readiness for spontaneous trial and extubation)
  - DVT prophylaxis.

3.3. Inclusion criteria

- Age >18yrs
- Mechanically Ventilated
- Admitted in MICU

3.4. Exclusion criteria

- Patients who are having contraindication for any one of the bundle approach
- Patients, who were intubated or on mechanical ventilation for more than 12 h before admission to the ICU

3.5. Sample size

The sample size is approx. 20 in each group (total sample size 40)

3.6. Outcome

- Primary outcome :

  VAP incidence

- Secondary Outcome :

  a) Mortality
  b) Total duration of Ventilation
  c) Days of ICU stay and Hospitalization

4. Statistical analysis

To compare the difference in the VAP incidence rates before and after Care bundle implementation and to find out the statistical significance Chi square test and unpaired student t test. Compliance rate of Care bundle is calculated as a percentage, VAP rate as number VAP /1000 ventilator days.

5. Results

After applying the inclusion and exclusion criteria, 40 patients were recruited in total. Most of the patients were critically ill at the time of recruitment with mean APACHE 2 score of 19.2 and 20.1 in the Pre and Post intervention phase respectively. The clinical profile of the recruited patients in both phases is summarized in (Table 1)

The laboratory profile of the recruited patients in both phases is summarized in (Table 3)

Both groups were comparable at time of recruitment. Most patients admitted were suffering from comorbidities and commonest ones were diabetes and hypertension and also there is history of antibiotic usage in patients within 3 month in both phases. Respiratory distress ,Respiratory failure and poor GCS were the main reason for intubation in majority of patients in both the groups. Diagnosis and complication of the study population of both the phases are summarized in (Table 2)

During the intervention phase, all the concerned residents and nurses who were directly or indirectly related to the care of mechanical ventilated patients attended the interactive session, lectures and one to one discussion during rounds. A total of 16 postgraduates and 20 nurses attended the sessions. None of the patients in the pre intervention group , where all the four components of the bundle implemented on all day of ventilation whereas in 20% of the patients in the post - intervention group , all the four components of the bundle were implemented on all days of ventilation. The compliance to Head end of the bed elevation was 78% that means if the patient in the group had total 100days of Ventilation , on 78 days the patient's head end was elevated to 30 to 45degrees . This was 99.5% in the post interventional phase. The compliance to Optimize sedation, Weaning protocol (checking for readiness for spontaneous trial and extubation) and DVT prophylaxis in the pre intervention phases were 38.8%, 35.9% and 42.7% respectively whereas it was 90.9%, 80.9% and 76% . and respectively in the post intervention phase.(Table 4) shows the compliance to the bundle components in the pre intervention vs post intervention phase.

Mean hospitalization days were 9.6 days in both pre and post intervention groups. The mean duration on Mechanical ventilation was 5.15 in pre intervention group and 6 in post intervention group .Mean ICU stay was 6.5 and 7.1 in Pre and Post intervention group respectively . None of these parameters were statistically significant .The Mortality of the post intervention is 5% less than Pre intervention group, though this difference was not statistically significant ($p < 0.72$) . The VAP rate was 38.8%/1000 ventilator days and 24.8/1000 ventilator days in pre and post intervention respectively and it is not statistically significant ($p< 0.67$). These findings comparing patients outcome summarized in Table 5.

The observed compliance to the four bundle components was compared in patients who had developed VAP with those who did not. It was observed that in patients who had developed VAP, compliance to the Optimize sedation , having weaning protocol and DVT prophylaxis was lower than the patients who did not developed VAP and the difference was statistically significant . The compliance to head end elevation was similar in both the groups , with or without VAP. A comparison of the bundle

Table 1. Clinical profile of the study population Pre and Post intervention

	Phase 1 (Pre intervention)	**Phase 2 (post intervention)**	**P value**
Parameter	**Summary (Mean ± SD)**	**Summary (Mean ± SD)**	
Age	55.5 ± 16.1	54.1±13.45	0.83
Gender	Male : Female = 14 : 6	Male : Female = 13:7	-
DM	13 (65%)	12(60%)	-
Hypertension	16 (80 %)	12 (60%)	-
Other Comorbidities	Hypothyroid -3 (15 %)	Hypothyroid -1 (5%) Parkinson 1 (5%)	-
Vaccination	Full dose of covid 19 vaccination - 11 (50%) Two doses of covid 19 vaccination - 6 (30%) One dose of covid 19 vaccination - 3 (15%) Other adult Vaccination - 0	Full dose of covid 19 vaccination - 11 (50%) Two doses of covid 19 vaccination - 6 (30%) One dose of covid 19 vaccination - 3 (15%) Other adult Vaccination - 0	-
Antibiotics usage in the past 3months	8 (40 %)	12 (60%)	0.2
Vitals(at the time of admission)	**Mean ± SD**	**Mean ± SD**	
Mean Arterial Pressure (MAP)	104.9 ± 26.6	92± 29	0.14
Pulse rate	83.2 ± 15.5	104.9±29.8	0.006
Respiratory Rate	23.5 ± 4.4	28 ± 5.1	0.004
Temperature	98.4 ± 1.1	98.75±1.7	0.5
GCS	7.2 ± 3	9.1 ± 4.1	0.10
SPo2	74.6 ± 15.5	82.1±15.5	0.13
APACHE 2	19.2± 2	20.1 ± 1	0.22

Table 2. Diagnosis and Complication of study population Pre and Post intervention*

Diagnosis	**Pre intervention**	**Post intervention**
CVS Ischemic Heart disease Arrhythmias Pulmonary embolism	1 0 0	3 2 1
Renal Chronic Kidney disease	3	2
Gastrointestinal Chronic Liver disease	2	2
Respiratory system COPD	1	1
CNS Stroke Seizure	5 0	1 3
Infection COVID Tropical Infection Pneumonia Urosepsis CNS Infection	0 0 0 1 (Pyelonephritis) 1 (Cryptococcus meningitis)	3 1 (leptospirosis) 1 0 0
Other Hanging Snake bite Poisoning DKA	2 1 2 1	1 0 0 3
Complication		
CVS Heart failure/ pulmonary oedema Cardiogenic shock	3 0	2 1
Respiratory Respiratory failure ARDS Aspiration Pneumonia	7 1 5	12 3 6
GI Hepatic encephalopathy Upper GI bleed Decompensation	2 0 5	2 2 0
Renal Acute Kidney injury	10	5
CNS Status epilepticus Hypoxic Ischemic encephalopathy	3 0	0 2
Infection Septic Shock Septic encephalopathy	2 0	1 1
Others Hyponatremia	0	1
Indication of Intubation		
Poor GCS	10	12
Respiratory distress and Respiratory Failure	11	12

Table 3. Laboratory profile of study population Pre and Post intervention

Lab parameter	Phase 1 (Pre intervention)	Phase 2 (post intervention)	P value
Complete blood count	**Mean ± SD**	**Mean ± SD**	
Haemoglobin	10.97 ± 2.3	13 ± 2.79	0.01
Total leucocyte count	16957 ± 6045	11352 ± 6278	0.06
Platelets	128100 ± 34861	166200 ± 78678	0.05
Renal function test			
Blood urea	69.8 ± 38.3	57.6 ± 24.4	0.23
Serum Creatinine	2.17 ± 1.7	1.82 ± 0.96	0.42
Liver function test			
Total bilirubin	2.9 ± 3.9	1.86 ± 2.1	0.27
SGOT	64.2 ± 89.4	128.8 ± 201.9	0.19
SGPT	74.5 ± 107.4	122 ± 197.7	0.35
Serum electrolytes			
Sodium	132.7± 5.3	134.1 ± 7.2	0.48
Potassium	3.9 ± 0.5	3.65 ± 0.54	0.12
Chest X ray	Aspiration pneumonia - 5 Pulmonary oedema - 3 COPD - 1 Multilobar consolidation - 1 Normal - 10	Aspiration pneumonia - 4 Pulmonary oedema - 2 Pneumonia -1 ARDS - 3 Normal - 10	-
ABG			
PH	7.33 ± 0.15	7.31 ± 0.18	0.7
HC03-	37.55 ± 11.8	38.7 ± 10.9	0.74
PCO2	17.45 ± 8.3	19 ± 9	0.57

Table 4. Compliance to the VAP bundle care in Pre and Post intervention

Bundle Component	Compliance rate (%) - Pre interventional	Compliance rate (%) - Post interventional	P value
Head elevation >30-45degree	74.7%	99.5%	0.00006
Optimize sedation (RASS 0 to -1)	38.8%	90.9%	0.00001
Weaning protocol	35.9%	80.9%	0.00001
DVT prophylaxis	42.7%	76%	0.0023

Table 5. Outcome of Study population in Pre and Post intervention

Primary Outcome	**Phase 1 (Pre intervention)**	**Phase 2 (post intervention)**	**P value**
VAP rate	38.8%/ 1000 ventilator days	24.8/1000 ventilator days	-
Total number VAP cases	4	3	0.67
Secondary outcome			
Mortality	Total -6 (30%) In VAP patient - 2	Total -5 (25%) In VAP patient - 1	0.72
Days of Mechanical Ventilation (days)	5.15± 2.4	6 ± 3.08	0.32
Days of ICU stay (days)	6.5 ± 3.1	7.1 ± 3.3	0.55
Days of Hospitalization (days)	9.6 ± 6.1	9.6 ± 4.6	1.0

6. Discussion

The whole idea of a VAP prevention bundle is that the implementation of the bundle components, would translate into better outcomes in terms of lower incidence of VAP, hospital mortality and hospital length of stay in patients on mechanical ventilation. Several studies highlight the fact that the incidence of VAP decreases with the use of bundles aimed at VAP prevention. The ventilator bundle designed by the Institute for Healthcare Improvement's (IHI) which was developed to improve outcomes of the ventilated patients was also shown to reduce the incidence of VAP [5].

Study conducted by al manoel to examine the effect of the IHI's ventilator bundle plus oral decontamination using a daily checklist which served as reminders to observe the five components resulted in improved adhesion to the whole bundle (9% and 86%) ($p < 0.001$) and lower incidence of VAP [6]. In this study we achieved 20% compliance to all the 4 components on all days of ventilation in post intervention group when compared to the pre intervention group where none of the patients had shown compliance with the all the four components of the bundle . This difference is lower than the magnitude of improvement achieved by the Barenholtz group (32 % in preintervention to 84% post-intervention) [7]. And also this study shows that there is statistically significant increases in compliance rate in all the components of VAP bundle except Head end elevation in post interventional group .

The present study showed that there is decrease in VAP rate from 38.8 to 24.8 per 1000ventilator days after the implementation of VAP bundle, though it is not statistically significant and it was observed that the reduction in the VAP rates correlates well with increase in bundle compliance rate . The results of this study showed a similar trend as that of a before and after cohort study done by Berenholtz in which the bundle decreased VAP rate from a median of 5.5 cases per 1000 ventilator-days at baseline to a median of zero cases at 16 to 18 months after implementation [7]. In comparison, study sample size of this study was smaller, had fewer days of ventilation and was of shorter duration. In a prospective longitudinal study conducted on adult intensive care unit (ICU) patients by Bukhari *et al.*, implementing a VAP prevention bundle reduced the VAP incidence rate and lowered the cost of care, the reduction being statistically significant [5].

The overall rates of VAP in both the pre and post-intervention phases in the present study were lower in comparison to the rates described in many other studies. In a study conducted by Dey *et al.*, in an ICU of an Indian tertiary hospital the incidence was found to be nearly 45 % [8]. In another Indian study done by Charles *et al.*, the incidence of VAP was found to be nearly 53 per 1000 ventilator days [9]. Probably a further study with a larger sample size would be needed to determine the effect of the proposed VAP prevention bundle on the incidence of VAP.

There was no significant difference in the mortality between the two groups. This study primarily focussed on VAP prevention bundle and not primarily on mortality reduction due to other causes. Similarly there was no significant difference in hospital stay, ICU stay and duration of mechanical ventilation between the 2 groups. This is following the trend of a study done by Boudama *et al.*, in which there was no significant difference in hospital mortality and duration of mechanical ventilation, though the ICU stay was lower post intervention unlike this study [10].

Gram-negative organisms were the predominant pathogens causing VAP infections in our study, a finding similar to other Asian studies [3]. In our study most common organisms were E.coli and K pneumonia similar to the study conducted by Nm Joseph *et al.*, which reports that most cases of VAP found in their tertiary

level ICU were caused by Gram-negative bacteria, (80.9%) such as Pseudomonas aeruginosa (21.3%) and A. baumannii (21.3%) [11].

We noted that a high proportion of our VAP infections too, were caused by MDR pathogens, including carbapenem-resistant organisms. This is cause for serious concern. "MDR" pathogens are referred to bacteria such as Pseudomonas species, Acinetobacter species, MRSA, and enteric Gram-negative bacilli expressing ESBL and AmpC β-lactamases and characteristically, displaying high levels of antibiotic resistance [1]. The INICC data from eight developing countries reported that Enterobacteriaceae species (26%, with 58% resistant to ceftriaxone) was the most common isolate found to cause VAP infections. This was followed by P. aeruginosa, S. aureus (77.5% of which were OXA resistant isolates) and Acinetobacter species (with 52.4% isolates resistant to carbapenems) [2]. A 9 month prospective study from an Indian tertiary care hospital reported a 45.4% incidence of VAP, which included 48% of MDR Acinetobacter infections and 27% of MDR Pseudomonas infections [8].

7. Conclusion

VAP prevention can be achieved to a large extent with the use of Bundle care approach .However, a major limitation is the lack of adherence to the set protocols by the health care professional especially in developing countries like India where the still the Patient to Nurse ratio is poor and overworked doctors . But one of the way to improve is by educating them through targeted training and using checklist which will help to improve adherence and ultimately patient outcome.

8. Limitation of the study

- Sample size is small ,
- Since the observation were carried out once in day and it was not possible to ascertain whether the bundle components were persistently adhered to,
- Confounding factors like adherence to hand hygiene, glove use, oral hygiene, appropriate suction methods etc. independently may lead to changes in incidence of VAP.

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