Brief Report

Introducing the Comprehensive Unit-based Safety Program for mechanically ventilated patients in Saudi Arabian Intensive Care Units

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Abstract:

Over the past decade, there have been major improvements to the care of mechanically ventilated patients (MVPs). Earlier initiatives used the concept of ventilator care bundles (sets of interventions), with a primary focus on reducing ventilator-associated pneumonia. However, recent evidence has led to a more comprehensive approach: The ABCDE bundle (Awakening and Breathing trial Coordination, Delirium management and Early mobilization). The approach of the Comprehensive Unit-based Safety Program (CUSP) was developed by patient safety researchers at the Johns Hopkins Hospital and is supported by the Agency for Healthcare Research and Quality to improve local safety cultures and to learn from defects by utilizing a validated structured framework. In August 2015, 17 Intensive Care Units (ICUs) (a total of 271 beds) in eight hospitals in the Kingdom of Saudi Arabia joined the CUSP for MVPs (CUSP 4 MVP) that was conducted in 235 ICUs in 169 US hospitals and led by the Johns Hopkins Armstrong Institute for Patient Safety and Quality. The CUSP 4 MVP project will set the stage for cooperation between multiple hospitals and thus strives to create a countrywide plan for the management of all MVPs in Saudi Arabia.

Key words:

Care bundles, Comprehensive Unit-based Safety Program, healthcare-associated infections, infection control, patient safety, ventilator-associated pneumonia

Mechanical ventilation (MV) is a core intervention in modern Intensive Care Units (ICUs) and is a life-saving therapy for many clinical conditions. Ventilator-associated pneumonia (VAP) is the most common healthcare-associated infection in ICU patients, with a reported incidence rate between 9% and 28% in some studies.[1-3] Although the estimates of VAP-attributed mortality are controversial,[4] a recent meta-analysis of 6284 patients from 24 trials reports an overall VAP-attributable mortality rate of 13%.[5] Infection with VAP is associated with an increased use of broad-spectrum antibiotics,[6] an additional 9.6 days of MV[7] and increased ICU stay from 4.3 to 13 days,[4] and infection ultimately costs an average of more than US$ 40,000 per episode.[8] As the global population ages and more multidrug-resistant organisms emerge, the burden of VAP is projected to increase even further.[9,10] Therefore, VAP prevention and improving the care of mechanically ventilated patients (MVPs) have become an essential focus for the entire health-care system, and possibly even a national safety goal for many countries.

The aim of the review is to assess the initiatives for improving the care for MVPs, specifically the Comprehensive Unit-based Safety Program for MVPs (CUSP 4 MVP), and the introduction of this program to Saudi Arabian ICUs.

The Evolution of Strategies for Improving the Care of Mechanically Ventilated Patients

Ventilator care bundles

In 2004, the Institute for Healthcare Improvement (IHI) 100 k lives campaign introduced the concept

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of a "care bundle" for the prevention of VAP.[11] A care bundle identifies a set of key interventions that, when implemented together as a best-practice approach, are expected to improve patient outcomes.[12] Resar *et al*. investigated the care bundle approach in a multicenter study involving 35 ICUs, and found that in the 21 units achieving >95% bundle compliance, the VAP rates decreased from 6.6 to 2.7 cases per 1000 ventilator days ($P < 0.001$); a 59% reduction.[13] More recently, Sinuff *et al*. showed that over a 2-year period, concordance with guidelines increased in another multicenter study involving 1320 patients, with a subsequent decrease in VAP rates from 14.2% to 8.8% ($P = 0.03$).[14]

Different combinations of ventilator care bundles have been reported. Table 1 summarizes the VAP bundle elements from eight international organizations. Elevation of the head of the bed from 30° to 45°, interruption of sedation on a daily basis, and daily assessment for extubation are endorsed by all the organizations. All organizations also endorse the use of endotracheal tubes with subglottic suctioning except the IHI bundle, which is the only organization to include peptic ulcer prophylaxis and deep venous thrombosis prophylaxis as elements in their bundle. A daily oral wash with chlorhexidine is endorsed by six of the eight organizations, and maintaining cuff pressure between 20 and 30 cmH_2O is advocated by half of the organizations. Furthermore, early mobility was included only in the recommendations of the US Centers for Disease Control and Prevention (CDC) and British Society for Antimicrobial Chemotherapy.

The ABCDE bundle: A comprehensive approach to improving the care of mechanically ventilated patients

In recent years, approaches to care have been broadened from focusing only on VAP prevention to focusing on a more comprehensive strategy on the basis of recent evidence of the benefit of the combined approach of the ABCDE bundle (Awakening and Breathing trial Coordination, Delirium management and Early mobilization).[15] The successful implementation of the ABCDE bundle requires improved communication among ICU team members, standardized care procedures, and better management of sedation, which will lead to reduction in delirium and weakness.[16] In addition, Balas *et al*. found that successful implementation of this bundle requires high-quality, timely, and reliable completion of independent tasks by trained individuals, effective communication between ICU team members, and effective leadership that can adapt to the needs of the local ICU culture and provide ongoing support, resources, and training.[17]

The Society of Critical Care Medicine released updated evidence-based guidelines for the management of pain, agitation, and delirium in ICUs (PAD guidelines).[18] The PAD guidelines prioritize treating and preventing significant pain, minimizing sedation, encouraging early liberation from MV, improving assessments and management of delirium, and facilitating early mobilization in the ICU. The guidelines recommend using sedation scales (the Richmond Agitation-Sedation Scale and the Riker Sedation-Agitation Scale) for managing sedation, and applying a target of both light levels of sedation and daily interruptions as techniques to reduce sedative exposure.

Wider outcome measurements

Although previous initiatives used VAP rates as the primary outcome measure, it has been increasingly recognized that MV causes harm beyond just VAP. Following the introduction of more comprehensive care bundles, such as the ABCDE bundle, wider outcome measures needed to be established to measure the benefit to patients and success of the program. The CDC, in conjunction with several critical care societies, convened a working group to address the limitations of the National Healthcare Safety Network definition of harm caused by MV, and they proposed a new approach.[19] Besides VAP, the new algorithm uses objective criteria for the diagnosis of ventilator-associated events (VAEs) and conditions (VACs) and infection-related ventilator-associated complications (IVACs).[20] This approach thereby broadens the definition of harm suffered by ventilated patients beyond pneumonia to include pulmonary edema, atelectasis, and acute respiratory distress syndrome.[21] The concept of VAEs has been validated and shown to be associated with longer MV treatment duration and ICU and hospital stays and higher mortality.[6,22-27] Klompas *et al*. showed that implementing simultaneous daily

Table 1: Comparing the bundle elements from several major institution and societies

Bundle Elements	Institutions and Societies							
	CA[49,50] 2008	UK[51] 2008	A/Z[52] 2010	ECDC[53] 2011	JH[54] 2011	IHI[11] 2012	SP[55] 2014	CDC[56] 2014
Elevation of the head of the bed –30 to 45°	Y	Y	Y	Y	Y	Y	Y	Y[a]
Daily sedative interruption	Y	Y	Y	Y	Y	Y	Y	Y
Daily assessment of readiness to extubate	Y	Y	Y	Y	Y	Y	Y	Y
Endotracheal tube with subglottic suctioning	Y	Y	Y	Y	Y		Y	Y[b]
Endotracheal tube cuff pressure		Y[c]		Y			Y	Y
PUD prophylaxis						Y		
DVT prophylaxis						Y		
Daily oral care with chlorhexidine	Y		Y	Y	Y	Y	Y	
Use Noninvasive Mechanical Ventilator		Y						Y
Selective oral or digestive decontamination							Y	Y
Facilitate early mobility		Y						Y

[a]There are very little data on head-of-bed elevation, but it is classified as a basic practice because of its simplicity, ubiquity, low cost, and potential benefit. [b]Moderate quality of evidence, [c]Good Practice Point. IHI = Institute for Healthcare Improvement, CDC = Centers for Disease Control and Prevention, JH = John Hopkins Hospital, CA = Canadian Patient Safety Institute, UK = United Kingdom, ECDC = European Centre for Disease Prevention and Control, SP Spanish Ministry of Health, A/Z = Australian Commission for Safety and Quality in Health Care, GI = Gastrointestinal, DVT = Deep vein thrombosis

spontaneous awakening trials and spontaneous breathing trials resulted in a significant reduction in VAC (63%) and IVAC (35%). In addition, the mean duration of MV declined by 2.4 days, ICU length of stay declined by 3.0 days, and hospital length of stay declined by 6.3 days after this.[27]

Comprehensive Unit-based Safety Program

The CUSP approach was developed by patient safety researchers at the Johns Hopkins Hospital (Baltimore, MD, USA) and is currently funded by the Agency for Healthcare Research and Quality (AHRQ) in the USA.[28] CUSP is designed to improve local safety cultures and to guide organizations to learn from mistakes by utilizing a validated and structured framework.[29-31] Key components include identifying evidence-based interventions that improve the outcomes of interest; converting these interventions into behaviors; placing value on the wisdom of frontline staff; and empowering frontline staff to be actively involved in safety improvements. This approach has been linked to multiple improvements in clinical and human resources outcomes, including large-scale reductions in healthcare-acquired infections,[32-35] mortality,[36] and associated costs.[37]

The CUSP intervention is a five-step iterative and validated process that aims to improve safety culture.[38] To implement the intervention, all participating units are requested to create a dedicated CUSP team. These teams ideally include a local physician and nursing champion, a senior executive, frontline health-care providers (physicians, nurses, and ancillary staff), an infection control provider, and hospital quality and safety leaders. Step 1 of the CUSP intervention educates staff on the science of improving patient safety, focusing on systems thinking and design. Step 2 asks the teams to identify local issues and/or defects, which are defined as anything that should not recur in either a clinical or operational context. Step 3 requires the unit to partner with a senior executive to help bridge the gap between the management and the frontline staff, prioritize safety hazards, and provide resources for local interventions. Step 4 introduces the staff to the tools that enable them to understand and learn from the identified local defects. Step 5 asks the teams to implement teamwork and communication tools.

Comprehensive Unit-based Safety Program-4 mechanically ventilated patients

In 2013, the Armstrong Institute for Patient Safety and Quality at the Johns Hopkins Hospital, Maryland, USA, in collaboration with the Michigan Health and Hospital Association Keystone Center and the Department of Population Medicine at the Harvard Medical School and Harvard Pilgrim Health Care Institute (Massachusetts, USA) launched the AHRQ-funded CUSP 4 MVP project. The program is a prospective cohort collaboration seeking to improve the care of MVPs and eliminate preventable harm associated with MV and is run in 235 ICUs in 169 US hospitals.

The project utilizes the CUSP concept; participating ICUs are instructed to create local unit-based multidisciplinary improvement teams (the CUSP teams). The project has three main tracks and one additional, optional track [Table 2]. Track 1 includes daily care procedures that include interventions that are applied to all MVPs: Specifically, elevation of the head of the bed to 30° or more, the use of subglottic suctioning, daily sedation and delirium assessments, and the daily performance of spontaneous awakening and breathing trials. Track 2 includes a daily early mobility assessment of all ICU patients; a nurse-led mobility program to achieve the highest level of mobility, and the identification of barriers to mobility and any clinical events associated with mobilizing patients. Track 3 combines both daily care procedures and daily early mobility assessments. Track 4 targets low tidal volume ventilation to prevent acute lung injury.[39]

Participating teams are invited to join collaborative monthly webinars and receive E-mails and updates through the Johns Hopkins CUSP 4 MVP project web portal (https://armstrongresearch.hopkinsmedicine.org/cusp4mvp.aspx). This portal provides educational materials for frontline staff, infection control practitioners, and allied health-care professionals; evidence-based toolkits; data collection tools to evaluate local practices; and a robust web-based data platform to generate real-time data reports. Participating ICUs can track their performance over time and compare their performance with others. Reports can be shared with team members, frontline staff, and hospital leaders to sustain engagement in the program.

Initiatives for Improving Ventilator Care in the Kingdom of Saudi Arabia

Most initiatives for improving ventilator care reported to date have focused on VAP prevention and have used the ventilator care bundle concept. A systemic review by Arabi *et al*. in 2008 found that the incidence of VAP in developing

Table 2: CUSP 4 MVP–VAP strategies for improving the care of ventilated patients

Track 1: Daily Care Process	Track 2: Early Mobility	Track 3: Daily Care Process + Early Mobility	Track 4: Lung-Protective Strategies
HOB ≥30°	Current level of mobility	Combination of track 1 and 3	Low TV 4-6 ml/Kg
Sedation at minimal level – sedation scale	Identification of barriers to mobility		PEEP ≥5 cmH_2O
Delirium assessment	Clinical events associated with mobility		Plateau pressure <30 cmH_2O
SAT			
SBT			
Use of SUB-G ETT			

HOB = Head-of-bed, SAT = Spontaneous awakening trial, SBT = Spontaneous breathing trial, SUB-G ETT = Endotracheal tube with subglottic suctioning, TV = Tidal volume; PEEP, positive end expiratory pressure

countries varied from 10 to 41.7 cases per 1000 ventilator days, with Saudi Arabia reporting a rate of 16.8 cases per 1000 ventilator days.[40] In 2014, the International Nosocomial Infection Control Consortium surveillance study involving 43 developing countries, including Saudi Arabia, reported a VAP rate of 14.7 cases per 1000 ventilator days,[3] which may reflect a small global improvement in managing ventilated patients during the previous 5 years.

Al-Tawfiq *et al*. conducted a prospective surveillance in Dhahran, Saudi Arabia, and found that VAP accounted for 19.8% of all device-associated infections in their hospital. During their study period (2004–2011), the implementation of a ventilator care bundle resulted in a significant decrease in the incidence of VAP from 8.9 to 1.9 cases per 1000 ventilator days, based on a pre- and post-implementation analysis.[41] In another prospective study in Riyadh, VAP rates decreased from 19.1 to 6.3 cases per 1000 ventilator days and bundle compliance improved from 49% to 99% over a 6-year period. In addition, this study found that VAP was associated with longer durations of MV (19.3 vs. 8.9 days, $P < 0.01$), stay in the ICU (22.2 vs. 10.7 days, $P < 0.01$), and stay in the hospital (85.5 vs. 61.6 days, $P < 0.01$). However, crude ICU and overall hospital mortality rates were similar in VAP and non-VAP patients.[42] Our group at King Abdul-Aziz Medical City, Riyadh, found that by employing a seven-element care bundle, the VAP rates declined significantly (8.6–2.0 cases per 1000 ventilator days, $P < 0.001$); however, there was no change in the duration of MV or ICU lengths of stay.[43]

Overall, several hospitals in Saudi Arabia have published findings on successful efforts to reduce VAP. We found seven articles that dealt with VAP prevention in Saudi Arabia [Table 3].[42-48] All these studies were based on pre- and post-intervention observational designs except for two, which were prospective cohort studies.[42,44] The total number of patient ventilator days was 64,414, with the highest number (41,034) reported by Al-Dorzi *et al*.[42] Cost estimates were mentioned in two studies: Bukhari *et al*.[45] calculated a cost of $56,400 per 1000 ventilator days, whereas Al-Tawfiq[46] estimated a cost of $41,000 per episode of VAP. An average of five elements was employed in each VAP preventive bundle, with all hospitals adopting the IHI care bundle. However, some organizations introduced other prevention measures. Four of the seven institutions added oral care with chlorhexidine,[43,44,47,48] two implemented the use of endotracheal tubes with subglottic secretion drainage,[43,48] and one monitored endotracheal tube cuff pressure.[43] The overall bundle compliance improved from 48.6% to 94.3% (an increase of 49%), with Al-Tawfiq and Abed[46] reporting the greatest improvement (75.6%). The average VAP rates decreased from 9.4 to 3.1 cases per 1000 ventilator days, which represents a reduction of 66%, and the biggest change (72%) was described by Al-Thaqafy *et al*.[44]

Comprehensive Unit-based Safety Program for mechanically ventilated patients (CUSP 4 MVP) to Saudi Arabian Intensive Care Units

In 2015, 17 ICUs in eight hospitals in Saudi Arabia (271 beds) joined CUSP 4 MVP. These health-care facilities include both private and government institutions, and they care for both acute and long-term ventilated patients. This project establishes the groundwork for cooperation between hospitals within Saudi Arabia to improve the quality of care in MVPs. The involvement of Saudi Arabian hospitals in this quality improvement project will help individual organizations grow and adapt evidence-based interventions to reduce VAC and VAP that can be used in daily, routine practice. Furthermore, this project will foster an environment to change the behavior of individual health-care workers and possibly the culture of the institutions. The project is currently ongoing and is expected to be completed in the end of 2016.

Table 3: Summary of published studies on VAP prevention in the Kingdom of Saudi Arabia

Study	Method				Δ Bundle compliance and VAP rates	
	Location	Study design	Sample[a]	Intervention	Δ Bundle compliance (%)	ΔVAP rates/cases per 1000 VD (%)
Tawfiq[46] 2010	Dhahran	Before/After 1/2006-12/2008	6866	IHI Bundles[b]	20→82% (↑=75.6)	9.3→2.5 (↓=73)
Bukhari[45] 2012	Makkah	Before/After 1/2010-12/2010	2747	IHI Bundles[b]	30→100% (↑=70)	2.5→1.7 (↓=37)
Al-Dorzi[42] 2012	Riyadh	Prospective 8/2003-6/2009	41,034	IHI Bundles[b]	49→99% (↑50.5)	19.1→6.3 (↓54)
Azab[47] 2013	Buryada	Before/After 6/2010-11/2011	992	IHI Bundles[b] CHX Oral Care	-→100	16.2→5.6 (↓65)
Garout[48] 2013	Jeddah	Before/After 2/2010-1/2011	3011	IHI Bundles[b] CHX Oral Care ET-SSD	17→92% (↑81)	8.9→3.2 (↓64)
Thaqafy[44] 2014	Riyadh	Prospective 6/2010-12/2013	9099	IHI Bundles[b] CHX Oral Care	86→99% (↑13)	3.6→1.0 (↓72)
Khan[43] 2015	Riyadh	Improvement Project 1/2011-12/2013	3665	IHI Bundles[b] CHX Oral Care ET-SSD	91→94% (↑3.2)	6.8→2.0 (↓71)

[a]Patient ventilator days: the number of patients managed with mechanical ventilators, collected daily at the same time each day [b]IHI (Institute for Healthcare Improvement) bundles: Head-of-bed elevation 30°-45°, daily sedation vacation and readiness to wean assessment, deep vein thrombosis (DVT) prophylaxis, and peptic ulcer disease (PUD) prophylaxis [c]Crude mortality increased after intervention but adjusted mortality was unchanged before and after the intervention. VAP = Ventilator-associated pneumonia, VD = Ventilator days, Δ = Change in, ↑ = Increase, ↓ = Decrease, - = No data available, ET-SSD = Endotracheal tubes with subglottic secretion drainage, CHX = Chlorhexidine, ICU = Intensive care unit, LOS = Length of stay

Conclusion

The important steps taken by the hospitals in Saudi Arabia participating in this program will help to standardize and improve the care of MVPs throughout the Kingdom, resulting in clinical best practices being applied to all patients, and thus ensuring better patient outcomes.

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Conflicts of interest
There are no conflicts of interest.

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