Use of bundled interventions, including a checklist to promote compliance with aseptic technique, to reduce catheter-related bloodstream infections in the intensive care unit

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BACKGROUND: A checklist that promotes compliance with aseptic technique during line insertion is a component of many care bundles aimed at reducing nosocomial infections among intensive care unit patients.
OBJECTIVE: To determine whether the use of bundled interventions that include a checklist during central-line insertions reduces catheter-related bloodstream infections in intensive care unit patients.
METHODS: A literature review was performed using methodology adapted from the American Heart Association's International Liaison Committee on Resuscitation.
RESULTS: Seventeen cohort studies were included. Thirteen studies were supportive of the intervention, while four were neutral. Infection rates ranged from 1.6 to 10.8 per 1000 central-line days in control groups, and from 0.0 to 3.8 per 1000 central-line days in the intervention groups.
CONCLUSION: There is fair evidence to recommend the use of care bundles that include a checklist during central-line insertion in intensive care unit patients to reduce the incidence of catheter-related bloodstream infections.

Key Words: *Catheters; Catheter-related infections; Checklist; Health care; Indwelling/adverse events; Infection control/methods; Intensive care units; Quality assurance*

Le recours à des interventions regroupées, y compris une liste pour favoriser le respect d'une technique aseptique, afin de réduire les infections sanguines liées aux cathéters à l'unité de soins intensifs

HISTORIQUE : Une liste de vérification qui favorise le respect d'une technique aseptique pendant l'insertion d'un cathéter fait partie de nombreux « soins regroupés » pour réduire les infections nosocomiales chez les patients à l'unité de soins intensifs.
OBJECTIF : Déterminer si le recours à des interventions regroupées, qui incluent une liste de vérification pendant l'insertion d'un cathéter central, réduit les infections sanguines liées aux cathéters chez les patients à l'unité de soins intensifs.
MÉTHODOLOGIE : Analyse bibliographique au moyen de la méthodologie adaptée du comité de liaison internationale sur la réanimation de l'*American Heart Association*.
RÉSULTATS : Dix-sept études de cohorte ont été incluses. Treize étaient favorables à l'intervention et quatre étaient neutres. Le taux d'infection variait entre 1,6 et 10,8 cas sur 1 000 jours-cathéters centraux dans les groupes témoins, et entre 0,0 et 3,8 cas sur 1 000 jours-cathéters centraux dans les groupes d'intervention.
CONCLUSION : Les preuves sont acceptables pour recommander l'utilisation de groupes de soins qui incluent une liste de vérification pendant l'insertion d'un cathéter central chez les patients de l'unité de soins intensifs pour réduire l'incidence d'infections sanguines liées aux cathéters.

Central venous catheters are essential for providing preterm and critically ill neonates long-term intravenous access for nutritional support and medication administration; however, they also place neonates at risk for catheter-related bloodstream infections (CRBSI). Recent estimates of CRBSI rates in neonatal intensive care units (NICUs) range from 3.5 per 1000 central-line days in infants weighing >2500 g to 9.1 per 1000 central-line days in infants weighing ≤1000 g (1).

Campaigns to reduce CRBSI (2-3) have included evidence-based practice 'bundles' composed of several interventions including hand hygiene, maximal barrier precautions, chlorhexidine skin antisepsis, optimal site selection and prompt removal of unnecessary central lines. Bundles have been shown to effectively decrease the incidence of CRBSI (4-5); however, it is not clear which component of the bundle is the most effective. The use of a checklist promotes compliance with best practices during central-line insertion and, thus, may be one of the more important components of the bundle.

As part of a series of quality improvement initiatives being undertaken by the Canadian Neonatal Network, we performed a systematic review to determine whether the use of bundled interventions that specifically include a checklist to promote compliance with aseptic technique during central-line insertion reduced the incidence of CRBSI in intensive care unit patients.

METHODS

Sources

The review was performed using methodology adapted from the American Heart Association's International Liaison Committee on Resuscitation (6). The MEDLINE, Embase and Scopus databases (January 1, 1966 to July 20, 2011) were searched using the following terms: ("quality assurance" OR "quality improvement" OR intervention OR bundle) AND (catheter OR catheterization OR line) AND (infection OR septicaemia OR bacteremia OR sepsis). Terms were matched to MESH or Emtree headings and exploded, and were also searched as free text. The Cochrane Library (July 2011, Issue 7)

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was searched using the following terms: ("quality assurance" OR intervention OR "quality improvement" OR bundle) AND (infections). The references of studies selected for full-text review and review articles were manually searched to identify additional studies. Only English-language articles were included.

Study selection

Randomized controlled trials, nonrandomized prospective studies, before and after comparisons, and retrospective studies with controls were included. All included studies used a checklist to promote adherence to the central-line insertion protocol and assessed the outcome of CRBSI in an intensive care setting. The objective of the present review was to assess checklists in NICU settings. However, due to a lack of studies involving neonates, the literature search was expanded to include all intensive care unit patients. An assumption was made that the processes of care would be similar in intensive care units for all age groups and that the results obtained could be generalizable to newborns in NICUs. Case reports, case series, noncontrolled studies, abstracts of unpublished studies, editorials, commentaries and review articles were excluded.

Study review

The level of evidence for each article was based on the Oxford Centre for Evidence-Based Medicine Levels of Evidence, May 2001 (7). The Oxford Centre for Evidence-Based Medicine Levels of Evidence were revised in 2011, after the present review was completed (8). The quality of evidence was also assessed using the following criteria: clarity of definition of comparison groups; uniformity and objectivity of outcome measurement in both groups; identification and control of confounding factors; and adequacy of follow-up. Studies fulfilling all four criteria were rated excellent; studies fulfilling three criteria were rated good; studies fulfilling two criteria were rated fair; and studies fulfilling less than two of the criteria were rated poor. Three of the authors (DS, JH and KL) independently reviewed all studies identified for inclusion. Discrepancies in determination of study design and quality were resolved by consensus after discussion among the three reviewers.

RESULTS

A total of 3303 studies were identified (some duplication was noted), and 73 were selected for full-text review after title and abstract review. A total of 17 studies (9-25) were selected for inclusion in the present review. All of the studies were cohort studies with either prospective or historical controls (level of evidence 2 or 3). Three studies were assessed to be of good quality, 10 of fair quality and four of poor quality. Study characteristics and methodological quality are summarized in Table 1. All of the studies included the use of a checklist as part of a systematic intervention or bundle. Outcomes were compared between groups receiving bundles and control groups not receiving bundles. No studies were identified that specifically compared the addition of a checklist to bundled interventions with bundled interventions without a checklist. The most common components of these multifaceted inventions were: use of maximum barrier precautions during insertion (n=17), hand hygiene (n=16), chlorhexidine for skin antisepsis (n=16), education (n=13), prompt removal of unnecessary lines (n=11), and use of dedicated central-line kits and/or supply carts (n=10).

Thirteen studies were supportive of the intervention and four studies were neutral. Among the neutral studies, Miller et al (17) showed that the only significant predictor of a decrease in CRBSI was the maintenance bundle rather than the insertion bundle; Miller-Hoover (19) found a large but statistically nonsignificant decrease in CRBSI, and Bonello et al (11) and Harrigan et al (14) implied support for the intervention but did not perform statistical analyses. Infection rates in control groups ranged from 1.6 to 10.8 per 1000 central-line days, while infection rates in the intervention groups ranged from 0.0 to 3.8 per 1000 central-line days.

DISCUSSION

Due to a lack of studies involving neonates, the literature search was expanded to include all intensive care unit patients. The migration of skin organisms along the catheter and colonization of the catheter hub are the most common mechanisms for the development of CRBSI. Thus, practices that minimize contamination of the skin or catheter with organisms have the potential to reduce CRBSI in patients of all ages. Schulman et al (23) studied patients in an NICU setting, and the results were supportive of the intervention. Miller-Hoover (19) included some neonatal patients, and three other studies (13,16,17) conducted in paediatric intensive care units likely also included some neonates.

Only the studies by Miller et al (18) and Wall et al (25) focused on the checklist as the primary, but not exclusive, intervention. Although all of the studies showed a decrease in the incidence of CRBSI, it is unclear to what extent these decreases were attributable to the checklist itself compared with the other bundle components. Peredo et al (20) reported that the most significant change between study and control periods was the implementation of a checklist. Miller et al (17) analyzed compliance with an insertion bundle and a maintenance bundle separately and found that only compliance with the maintenance bundle was related to a decreased incidence of CRBSI. Interestingly, the decrease in infection rate in the studies in which the checklist was the primary intervention (18,25) was approximately 45% to 60%, similar to the magnitude of effect observed in the other studies.

There were several common methodological limitations to the reviewed studies. Most of the studies failed to include sufficient data regarding patient characteristics in the intervention and control groups to ensure comparability. Only three studies (17,21,23) attempted to correct for confounding factors in their analysis. Two of these studies were supportive of the intervention (21,23) while the other study was neutral (17). Thus, the differences in CRBSI rates may be due to patient factors and confounders rather than the effect of the intervention. The duration of follow-up for outcome determination was also not clearly defined in any of the studies.

Although the magnitude of benefit from the use of checklists may be questionable, checklists are likely a safe intervention. While implementing these systematic interventions would potentially require additional resource allocation, there would also be economic benefits from the infections prevented. Berenholtz et al (9) included an economic analysis and estimated that the intervention saved approximately $1.9 million. Thus, it appears to be likely that the savings related to declining infection rates would offset any costs incurred during implementation.

CONSENSUS ON SCIENCE

There is fair evidence supporting the use of bundles that include a checklist during central-line insertion to reduce the incidence of CRBSI.

RECOMMENDATIONS

We recommend the use of bundled interventions that include a checklist during central-line insertion in intensive care unit patients to reduce the incidence of CRBSI.

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TABLE 1
Characteristics of included studies

Author (reference), year	Setting	Sample size (central line days)		Clear definition of comparison groups	Confounders identified and controlled	Intervention components in addition to the checklist	Objective, uniform outcome assessment	Follow-up	Infection rate (per 1000 central-line days)		LOE	QOE
		Intervention group	Control group						Intervention group	Control group		
Berenholtz et al (9), 2004	Adult ICU	19,905	17,383	Yes	No	EDU, HH, MBP, CLC, DAL	Yes	At least 48 h post-discharge	0.0	1.6	2	Fair
Berriel-Cass et al (10), 2006	Adult ICU	Not reported	Not reported	Yes	No	EDU, HH, MBP, AFS, CHL, CLC	Yes	Not clearly reported	3.0	9.6	3	Fair
Bonello et al (11), 2008	Adult ICU	Not reported	Not reported	Yes	No	EDU, HH, MBP, AFS, CHL, DAL	Yes	Not clearly reported	2.7	5.2	2	Fair
Burrell et al (12), 2011	Adult ± paediatric ICU	Unclear	Unclear	No	No	HH, MBP, CHL, line position checked by imaging or pressure transducer	Unclear	Not clearly reported	1.2	3.0	2	Poor
Costello et al (13), 2008	Paediatric ICU	3675	2951	Yes	No	EDU, assessment of vessel patency, HH, MBP, CHL, CLC, DAL	Yes	At least 48 h post-discharge	2.3	7.8	3	Fair
Harrigan et al (14), 2006	Adult ICU	Not reported	Not reported	Yes	No	EDU, HH, MBP, CHL, CLC, IV hang time policies changes, DAL	Not reported	Not clearly reported	1.1	3.8	3	Poor
Longmate et al (15), 2011	Adult ICU	2138	2660	Yes	No	MBP, CHL, AFS, maintenance bundle (includes DAL)	Unclear	Not clearly reported	0.0	3.4	3	Poor
McKee et al (16), 2008	Paediatric ICU	~2200 (300 per quarter)	~3000 (300 per quarter)	Yes	No	EDU, HH, MBP, CHL, CLC, weekly feedback	Yes	Not clearly reported	3.0	5.2	3	Fair
Miller et al (17), 2010	Paediatric ICU	95,205	Not reported	Yes	Yes	EDU, HH, MBP, CHL, CLC, Teflon or polyurethane catheters only, maintenance bundle (includes DAL)	Yes	Not clearly reported	3.1	5.4	3	Good
Miller et al (18), 2010	Adult ICU	3283	4116	Yes	No	EDU, HH, MBP, CHL, chlorhexidine biopatch, antibotic coated catheters	Yes	Not clearly reported	3.4	8.5	2	Fair
Miller-Hoover (19), 2011	Paediatric ICU	2052	1210	Yes	No	HH, MBP, CHL, DAL, maintenance bundle	Yes	Not clearly reported	1.5	4.9	2	Fair
Peredo et al (20), 2010	Adult ICU	3296	3572	Yes	No	EDU, HH, MBP, CHL, AFS, DAL	Unclear	Not clearly reported	2.4	6.7	3	Poor
Pronovost et al (21), 2006	Adult ICU	375,757 (both groups combined)		Yes	Yes	EDU, HH, MBP, AFS, CHL, CLC, DAL, feedback	Yes	Not clearly reported	1.4	7.7	2	Good
Render et al (22), 2006	Adult ICU	10,472	Not reported	Yes	No	EDU, HH, MBP, CHL, CLC	Yes	Not clearly reported	0.4	1.7	3	Fair
Schulman et al (23), 2011	NICU	55,137	61,096	Yes	Yes	HH, MBP, CHL, CLC, sterile gauze / transparent semi-permeable dressing, maintenance bundle (includes DAL)	Yes	Not clearly reported	2.1	3.5	2	Good
Venkatram et al (24), 2010	Adult ICU	1670	4797	Yes	No	EDU, HH, MBP, AFS, CHL, CLC, DAL feedback	Yes	Not clearly reported	1.7	10.8	3	Fair
Wall et al (25), 2005	Adult ICU	630 lines	Not reported	Yes	No	EDU, HH, MBP, CHL, continuous audit, performance feedback	Yes	At least 48 h post-discharge	3.8	7.0	3	Fair

~ Approximately; AFS Avoiding femoral site; CHL Chlorhexidine antisepsis; CLC Central line cart; DAL Daily assessment of line necessity; EDU Education; HH Hand hygiene; ICU Intensive care unit; LOE Level of evidence; MBP Maximum barrier precautions; NICU Neonatal ICU; QOE Quality of evidence

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