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ORIGINAL ARTICLE

Hand hygiene and catheter related bacteraemia rates in ICU patients in Latvia during five years, before and after interventions

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Abstract

Implementation of a procedure of evidence-based measures resulted in reduced incidence of catheter related bacteraemia from 13.3 to 2.1 cases per 1000 bed days. This improved the results of patient treatment, and shortened the length of hospitalisation.

Correct personnel hand hygiene is one of the infection control measures. The results obtained during the study showed that at the beginning hand hygiene compliance indicators were very low (8%), but after implementing targeted measures, these results improved.

Key words: hospital-acquired infection, hand hygiene, catheter-related bacteremia

Introduction

There is no catheter-related bacteraemia (CRB) monitoring programme in Latvia on the national level. Implementation of such a programme would enable planning of proof-based interventions that could reduce the numbers of CRB cases. This work was initiated to detect the CRB-related morbidity rate (incidence) as well as the most frequent risk factors in an intensive care unit of a major teaching hospital, and to research the influence of control measures on the CRB infection rates. The results of the research could be used in planning and development of programmes for monitoring and controlling healthcare-associated bacteraemias in Latvia.

The USA Centre for Disease Control and Prevention (CDC) suggests at least five measures to reduce CRB, provided all measures are taken. The major measures are: personnel hand hygiene (at the time of insertion of a catheter and performing the treatment and therapy of a patient), usage of maximum sterile barrier precautions, treatment of the skin with chlorhexidine,

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as well as using the optimal place for the insertion of the catheter, evaluation of the necessity of usage of the inserted catheter, relevant care of the catheter, etc.[1]

Methods

A time-series prospective study about bacteraemias was carried out in an adult medical intensive care unit (ICU) with 19 beds, in Pauls Stradins Clinical University Hospital (PSCUH), a multifunctional university hospital in Latvia. The duration of the study was 4.5 years-from 20 August 2008 until the end of June 2013. The study was divided into five major phases, and three significant interventions by infection control nurses were carried out during the whole study period. Throughout the study, bacteraemia results for ICU patients were recorded. Hand hygiene monitoring was performed by infection control nurses.

The identification of bacteraemia was based on Centers for Disease Control and Prevention criteria. Only bacteraemias confirmed by laboratory for ICU patients were included into the study. No changes in blood cultures procedure in the hospital were performed during the study. Blood cultures for patients were performed by ICU nurses after physician decision. For CRB analysis HAI-Net criteria CRI3 were applied.[1] Medical history, laboratory reports and documentation related to the treatment of the patients were used as data sources for the study.

A special procedure for CVC insertion, treatment and removal was implemented in the hospital in 2009. The procedure was based on CDC guidelines, and included maximal sterile barrier requirements, documentation in the medical history of the patient and daily Central venous catheter (CVC) usage review.

All ICU patients with a CVC inserted in the operating room or ICU were included in the study if they had the CVC for more than 24 hours. If the CVC insertion was performed in another ward of the hospital, patients were excluded from the study. Patients with tunnelled CVC, port systems, and peripherally inserted catheters were also excluded. Registration of CVC was performed until the catheter was removed or the patient died or was discharged.

For hand hygiene (HH) monitoring, the World Health Organisation (WHO) Hand Hygiene Monitoring Tool was used. HH was monitored by infection control nurses.[2]

Phase I: collection of information about the cases of bacteraemia in ICU patients and their causes. All the ICU patients admitted in ICU for more than 24 hours were included in the study. During the first 6-month phase, passive monitoring of medical staff HH was performed without intervention.

Phase II: monitoring of HH practices was carried out as during the first phase. Education in hand hygiene for ICU medical staff (nurses, nurse assistants / ward attendants) started. Theoretical and practical training of medical staff, using the DVD material prepared by WHO, was also performed. Data collection about bacteraemia was continued in all ICU patients. Daily patient washing with CHG solution was initiated.[3,4]

Phase III: the data collection from the first and second phase continued, but the activities of HH intervention were slightly changed. The results of the first and second HH monitoring phases were analysed together with nurses, nurse assistants / ward attendants and also with doctors and interns. Reminders about HH during patient care were performed.

Phase IV: HH monitoring was continued, but active intervention and reminders to ICU staff was not continued. Specific HH training was provided only for the medical staff that started working in the ICU. Data collection about bacteraemia was continued and observations for CVC insertion and care started. A procedure for CVC insertion, treatment and removal was introduced in the hospital in 2009. The procedure was based on CDC guidelines."

During this phase, CVC insertion was compared with the CDC requirements."

Phase V: HH monitoring and bacteraemia data collection was continued during this phase. The author of this study in collaboration with the staff of the ICU composed a special procedure for the insertion of the catheter. For the skin preparation before CVC insertion, the hospital pharmacy prepared a solution of chlorhexidine 2% in ethanol. The new catheter

insertion and care procedure was fully implemented in the ICU in May–June of 2012. During the period of the intervention, educational training of the medical staff was performed.[5]

Statistics

The software EpiData 2.1 was used to process the data. Chi-squared tests and odds ratios were applied. Results were considered statistically significant if $p < 0.05$. The relations between hand hygiene performance and CRB rates were also studied with regression analysis.

Results

Length of stay with and without bacteraemia

In Phase IV (November 2010 – March 2012) 802 patients spent mean 7.9–8.8 days in the ICU. Patients with bacteraemias stayed longer (mean 23 d) than patients without bacteraemias (mean 9.9 d) ($p < 0.01$).

In Phase V (April 2012 to June 2013) 727 patients spent from 7.4–8.2 days in the ICU on average. For bacteraemia patients, the time of hospitalisation was longer (mean 19 d) than for those without bacteraemia (mean 9.6 d) ($p < 0.01$).

The time of hospitalisation for patients with bacteraemia in both time periods was statistically equal. The time spent in hospital by men and women did not differ.

Hand hygiene (Table I)

From 20 August 2008 to 28 June 2013, 5739 hand hygiene observations were performed. In Phase II compliance with the requirements of hand hygiene was 8.2 times greater than during Phase I and it increased to 13.8 times during Phase III. In Phase II and V the compliance rates sank to 7.2 times that of Phase I.

The highest hand hygiene compliance was reached at the third indication – after the contact with biological fluids of a patient, but the least pronounced improvement was at the first indication – before the contact with a patient. The lowest level of hand hygiene was detected at the fifth indication – after the contact with the equipment used by a patient. In total, the highest rate of hand hygiene compliance per three-month period was reached in the group of nurses reaching 40% (95% CI: 38.14–41.89), but for the doctors the rate was 35% (95% CI: 32.77–37.25). For nurse assistants / ward attendants the average ratio of hand hygiene compliance was 36% (95% CI: 33.31–38.80). For other groups the average ratio of hand hygiene compliance was 17% (95% CI: 12.54–22.15).

In Phase IV - V, overall hand hygiene compliance declined to 40%. Hand hygiene before the performance of the aseptic procedure was still 60% and after contact with biological fluids of a patient 58%.

Catheter-related bacteraemia

Before the CVC procedure was introduced 68/802 (8%) of the patients had bacteraemia, but after the introduction of the changes in application of CVC the bacteraemia rates were reduced to 22/727 (3%). During phase I of the study, the incidence of bacteraemia was 23.3 per 1000 bed-days. The most frequent causes for bacteraemia in the ICU patients were *Acinetobacter baumannii, Staphylococcus aureus,*

Table I. Hand hygiene compliance and total bacteraemia rates throughout the study

Phase	Hand hygiene observations (n)	Hand hygiene compliance rate (%)	OR (95% CI) per three-month period compared with phase I	Total bacteraemia rate / 1000 bed days
I	1274	8.5	1	23
II	890	43	8.16 (6.39–10.42)	18
III	1369	56	13.76 (10.93–17.33)	19
IV	2206	40	7.19 (5.77–8.97)	19
V				14

Pseudomonas aeruginosa, Staphylococcus epidermidis and *Enterobacter cloacae*. More than 50% of all CRB during Phases I-III were caused by *A. baumannii*. Initially, *S. epidermidis*, *Klebsiella pneumoniae, S. aureus, P. aeruginosa*, as well as *E. cloacae* were also diagnosed as frequent causes of CRB. In Phases IV and V an increase in the spread of multi-resistant microorganisms was experienced but rates of CRB decreased from 10.1 (95% CI: 7.9–12.8) to 3.8 (95% CI: 2.5–5.8) per three-month period (Table II).

Information on all ICU patients (n=1066) with CVC catheter inserted was collected. Analysis of the data on 1429 CVC was performed, including 12,485 catheter days. The highest CRB rate was for patients that spent less than a day at ICU after CVC insertion. Such indicators were detected temporarily for patients at both stages of the study. Similarly, relatively higher CRB indices were for patients who spent more than 20 days in the ICU. The lowest figures were for patients who spent not more than 5 days in the ICU.

The insertion sites were also analysed For CVC that were inserted into *v.subclavia*, the CRB rates reduced several times during the period of intervention. The highest rates of CRB in Phase IV reached 12.2 (95% CI: 6.4–24.3), but in Phase V the lowest index was equal to 1.4 (95% CI: 0.210.3). For CVC that were inserted into *v.jugularis*, the CRB rates were also reduced. The highest point that CRB reached in Phase IV was 15.8 (95% CI: 7.9–31.7) but during Phase V the lowest rate was 1.7 (95% CI: 0.2–12.2). CVC inserted into *v.femoralis* had the highest rate of CRB. The highest figures of CRB for this group of catheters was 22.9 (95%CI: 7.4–71.0), but the lowest rate was 9.7 (95% CI: 1.5–74.7). In all, catheters inserted into *v.femoralis* had the highest rates, and catheters inserted into *v.jugularis* had the lowest.

Analysis of the ward where the CVC was inserted showed that the highest CRB incidence rates were for CVCs inserted during surgery (in an operating room). In Phase V, the greatest CRB incidence reduction was seen when the intervention was carried out in the ICU.

Figure 1 shows the CRB rates for Phases IV and V in relation to the time the CVC remained in place. The highest CRB indicators in Phase IV were for the catheters that were used for longer than 20 days. The indicators of CRB incidence for this group were equal to 18.5 (95% CI: 8.2–36.7). In Phase V, no catheters were used for longer than 20 days. Despite the fact that CRB incidence rates were reduced in all groups during Phase IV, the CRB incidence for CVC used from 10 to 19 days still remained relatively high (initial incidence rate 14.7; 95% CI: 11.1–19.2). During Phase V rates were further reduced to 7.2 (95% CI 4.5–15.5). The most pronounced reduction in CRB incidence rates during Phase V was for CVCs that were used for less than five days (initial CRB indicators were 3.8; 95% CI: 2.0–7.1; and during the intervention they were reduced to 0.4; 95% CI: 0.1–2.4). The most frequent

Table II. ***CRB incidence ratios in Phase IV and V***

Time period		CRB incidence per bed-days (95% CI)
Phase IV	January–March 2011	10.3 (6.2–17.1)
	April–June 2011	13.3 (8.2–21.3)
	July–September 2011	9.7 (5.5–17.1)
	October–December 2011	8.8 (5.0–15.4)
	January–March 2012	8.4 (4.8–14.8)
Phase V	April–June 2012	4.9 (2.2–10.8)
	July–September 2012	5.2 (2.3–11.5)
	January–March 2013	2.1 (0.5–8.3)
	April–June 2013	2.8 (0.9–8.6)

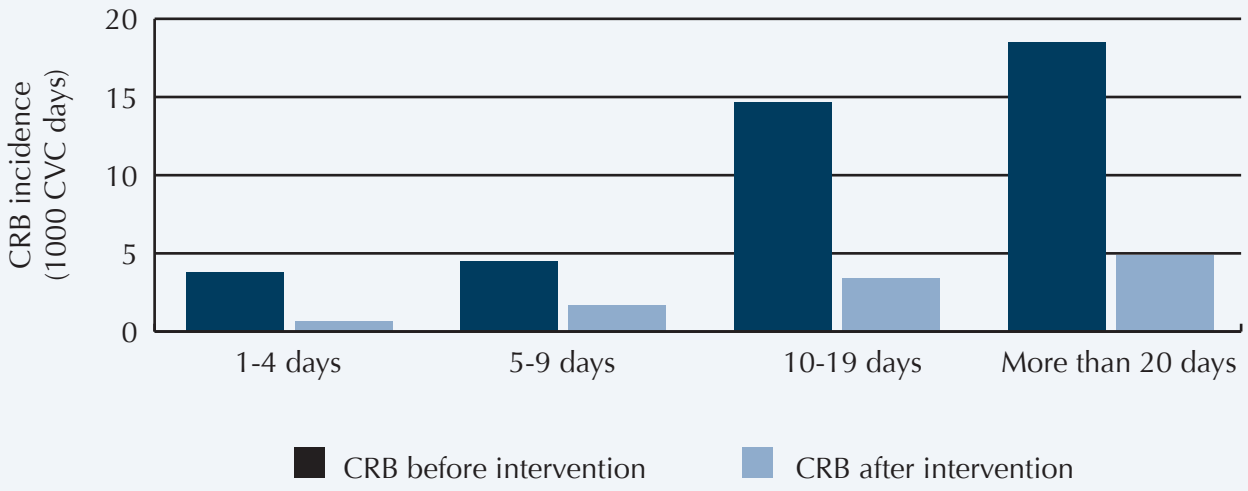

Figure 1. ***CRB incidence ratio and CVC duration before and after the intervention***

duration of usage of the catheters for patients was from 10 to 91 days; however, during the intervention this trend amended. Furthermore, the number of CVCs used no longer than four days increased significantly during the intervention (Figure 1).

In Phase I of the study, the average duration of the usage of a catheter was eight days, but during the period of the intervention, it reduced by one day (the average duration on the fourth and fifth phases of the study was 7–9 days).

An evaluation of the CVC procedure was carried out during Phases IV and V of the study. In Phase IV, 188 CVC insertions were observed and during Phase V 116 CVC insertions. In Phase IV, 2% chlorhexidine solution was not used and requirements for maximum sterile barriers were not followed. There was also a failure to perform relevant hand rub and change of sterile gloves to provide aseptics. Daily CVC usage review was not performed or noted in the patient files.

In Phase V, an average 71% per three-month period (95% CI: 61.84–78.20) of CVC insertion compliance was reached. The highest compliance rate was reached in January–March 2013 (95% CI: 71.93–95.02).

The total bacteraemia rates at the ICU throughout the study period and its relation to the performed interventions are shown in Table I and in more detail in Figure 1.

Discussion

The incidence rate of bacteraemia, compliance of hand hygiene, and catheter-related bacteraemia (CRB) were analysed in the intensive care unit of a teaching hospital in Latvia.

No hand hygiene promotion project on such a scale has been implemented in any other hospital of Latvia. No other studies on hand hygiene had been conducted in Latvia so far. Neither had interventions on hand hygiene. No changes in training of medical staff in infection control had been implemented. It was not possible to define the average hand hygiene rate in hospitals on the whole, but it could be assumed that the rates in Pauls Stradins Clinical University Hospital were representative also of other wards/hospitals. This is also the first attempt to apply CRB definitions in Latvia and to compare data on the CRB incidence in a Latvian hospital to international data.

Hand hygiene

The study was conducted during five consecutive phases. Phases I, II and III can be described as introduction, teaching and monitoring of hand hygiene as well as baseline measuring of bacteraemia rates. In Phase IV and V there was no active intervention. Initially the compliance of hand hygiene was very low. The highest rates of hand hygiene compliance were seen during the third phase, when the feedback with the medical staff concerning the acquired results and their changes was established. The decline of

compliance in Phase IV-V implies the necessity of repeated monitoring and feedback of HH practices as well as continuing persistent implementation of hand hygiene promoting activities.

The observations carried out at Pauls Stradins Clinical University Hospital showed that the highest level of hand hygiene was maintained in the nurse group. The fact that nurses had a more frequent contact with patients than doctors or nurse assistants / ward attendants should also be taken into the consideration.

The highest hand hygiene compliance was reached at the third indication – after the contact with biological fluids of a patient, but the least pronounced improvement was before the contact with a patient. This could be explained by the fact that hand rub after the contact with biological fluids of a patient protected staff from microbiological contamination and possible infection, but the first indication was meant for the protection of a patient. This trend, that staff was more oriented to self-protection and ignoring the protection of a patient, has been repeatedly detected in hand hygiene research. The lowest level of hand hygiene was detected after contact with the equipment used by a patient. This could be due to the fact that staff had not been thoroughly informed about patient zone principle, zoning of a patient ward as well as its equipping. On the whole, the research of habitual behaviour and the development of the science concerning the compliance of hand hygiene enabled us to understand the obstacles that prevent the practice of good hand hygiene in health care institutions.[2,12,13,14]

Catheter-related bacteraemia

The duration of the hospitalisation of a patient with bacteraemia was twice as long as that of a patient without bacteraemia.

Before the study CVC was inserted without maximal sterile barrier requirements and daily CVC usage review. An in-depth research on risk factors of CRB was carried out at intensive care unit starting with Phase IV. During this phase, changes in the procedure of CVC insertion were introduced. The overall results of the phase showed that staff focused on other urgent matters (CVC, monitoring of bacteraemias) and did not actively monitor hand hygiene.

A special procedure for CVC insertion, treatment and removal was introduced into the hospital in 2009. The procedure was based on CDC guidelines1. On application of the procedure, the CVC usage practice dramatically changed, mostly the manipulation is available only in ICU, and documentation of CVC treatment as an integral part of the medical history of a patient became strictly required. The study conducted at PSCUH managed to reduce the number of healthcare-associated bacteraemia by more than 50%.

Daily patient washing with CHG solution was initiated as the usage of CHG solution has been shown to reduce healthcare-associated infection (HAI) incidence especially in ICU.[3,4]

The most intensive CRB incidence reduction was observed during the fifth phase of the study, when the procedure for CVC was improved. The introduction of CVC procedure helped to reduce the rates of CRB from 10.1 (95% CI: 7.9–12.8) to 3.8 (95% CI: 2.5–5.8) in a short period of time. The average duration of catheter use was reduced by one day. The average time spent by a patient at ICU was also reduced by one day (p=0.018). The duration of the hospitalisation of a patient with bacteraemia was twice as long as that of a patient without bacteraemia. By reducing the probability to acquire CRB, it was possible to reduce the time of hospitalisation of patients.

The change of practice of all the personnel in ICU through training and changes in procedure standards was very effective in PSCUH although the compliance reached only 71%. To continue the observation of procedure standards and personnel training up to100% compliance, it could be possible to further reduce catheter-related bloodstream infection (CRB) rates.[9,10,11] Patients in our study that spent less than a day at ICU before transfer to other wards had the highest CRB rates, which confirmed the Swiss findings, as only ICU staff were trained and no intervention was provided to the other hospital staff.

The least reduction of CRB was observed for catheters in use for more than 10 days. In order to reduce these CRB rates, it is necessary to work more on changes in the nurse practice standard (introducing chlorhexidine use for catheter connector and skin treatment as well

as introducing the treatment of catheter connectors before each catheter usage).

The multimodal approach in reducing CRB rates has justified itself as the results of these coordinated activities (interventions) indicate the successful choice of infection control methods in the monitoring of CRB.

Conclusion

The introduction of a special CVC procedure in the ICU was more effective method than hand hygiene intervention for the prevention of CRB. Both these methods should be applied for the reduction of CRB in PSCUH as well as in other hospitals. Although the effectiveness of both interventions used has been shown in the literature, most attention should be paid to implementation of the CVC bundle, thus focusing attention on an invasive high-risk procedure practice for a short period of time. This conclusion should be taken into account while planning the monitoring and intervention of other HAIs because not always health care institutions have enough resources to achieve HAI reduction by introducing several infection control methods at the same time. The results of the study could also be used to develop the practice of high-risk units.

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