Intensive Care Med
DOI 10.1007/s00134-007-0559-5

BRIEF REPORT

David Bracco
Marc-Jacques Dubois
Redouane Bouali
Philippe Eggimann

Single rooms may help to prevent nosocomial bloodstream infection and cross-transmission of methicillin-resistant *Staphylococcus aureus* in intensive care units

Received: 11 February 2006
Accepted: 24 January 2007

Conflict of interest: None

D. Bracco (✉)
Montreal General Hospital, McGill University Health Center, Department of Anaesthesia,
Room D10-145-3, 1650 Cedar Avenue, H3G 1A4 Montreal, Canada
e-mail: david.bracco@mcgill.ca
Tel.: +1-514-9341934 ext 43030
Fax: +1-514-9348249

D. Bracco · M.-J. Dubois
Montreal University Hospital, Intensive Care Unit, Department of Medicine, Montreal, Canada

R. Bouali
Ottawa General & Civic Hospital, Intensive Care Unit, Department of Medicine, Ottawa, Canada

P. Eggimann
Centre Hospitalier Universitaire Vaudois (CHUV), Department of Intensive Care Medicine,
Lausanne, Switzerland

Abstract *Objective:* Nosocomial infections remain a major problem in intensive care units. Several authorities have recommended housing patients in single rooms to prevent cross-transmission of potential pathogens, but this issue is currently debated. The aim of the present study was to compare the rate of nosocomial cross-contamination between patients hosted in single rooms versus bay rooms. *Design:* Prospective observational data acquisition over 2.5 years. *Setting:* A 14-bed medico-surgical ICU, composed of six single-bed rooms plus a six-bed and a two-bed bay room served by the same staff. *Patients and participants:* All patients admitted from 1 July 2002 to 31 December 2004. *Interventions:* None. *Measurements and results:* Prevalence of methicillin-resistant *Staphylococcus aureus* (MRSA) in admitted patients was 1.1% and acquisition rate 2.4%. The incidence density of MRSA acquisition was 4.1 [95% CI 2.7–6.3]/1,000 patient-days in bay rooms versus 1.3 [0.5–3.4]/1,000 patient-days in single rooms ($p < 0.001$). *Pseudomonas* spp. acquisition rate was 3.9 [2.5–6.1]/1,000 patient-days in bay rooms versus 0.7 [0.2–2.4]/1,000 patient-days in single rooms ($p < 0.001$), and *Candida* spp. colonization was 38.4 [33.3–44.1]/1,000 patient-days in bay rooms versus 13.8 [10.2–18.6]/1,000 patient-days ($p < 0.001$). By multivariate analysis, the relative risk of MRSA, *Pseudomonas aeruginosa* and *Candida* spp. acquisition in single rooms or cubicles versus bay rooms was 0.65, 0.61 and 0.75 respectively. *Conclusions:* These data suggest that in an institution where MRSA is not hyperendemic, infection control measures may be more effective to prevent cross-transmission of microorganisms in patients housed in single rooms.

Keywords Infection control · Cross infection/epidemiology/*etiology/*prevention & control · Handwashing · Critical care · Hygiene · Prospective studies

Introduction

Nosocomial infections add substantial morbidity and mortality in many intensive care units (ICUs) [1]. Among measures to prevent cross-transmission of pathogens, European and other authorities recommended single rooms, aimed at enhancing compliance with infection control measures, in the design of intensive care units [2]. However, the impact of such specific architectural standard became controversial [3, 4]. In a recent study, Cepeda et al. strongly questioned the value of such measure in the prevention of methicillin-resistant *Staphylococcus aureus* (MRSA) cross-transmission in ICUs [5]. This study confirms the doubts raised by Cooper et al., one of its co-authors, in a systematic review on precautions to prevent the spread of MRSA in hospitals [6].

Infection control practices may be adapted accordingly in the near future in many ICUs. Confronted, like many other colleagues around the world, with cost constraints without reducing the quality of care, we were particularly interested by such simplification of care. Before modifying our concept of infection control, however, we decided to analyze the data prospectively collected from our medico-surgical ICU, including single rooms and bay rooms, to determine the possible impact of single rooms on the rates of MRSA acquisition.

Methods

The Hôtel-Dieu de Montreal Hospital is a 302-bed tertiary teaching hospital affiliated to the University of Montreal. A 14-bed medico-surgical ICU was built in the walls of a regular ward in 1970 and comprises six single rooms, including two single-bed rooms with negative pressure facility, one room with four distinct cubicles considered as single rooms for the analysis, and two bay rooms of six and two beds (Fig. 1). The standard nurse-to-patient ratio was 1:2. In bay rooms the area per bed is between 7.1 and 7.2 m^2 and in cubicles it ranges from 8.7 to 9.2 m^2. An average of 1,000 patients are admitted yearly, half of them following cardiac and major vascular surgery and half of them for a non-operative medical condition. Patients admitted for non-complicated coronary syndromes were hosted in a separate coronary unit that was not part of this investigation.

Prospective computerized data acquisition from the case-mix started in July 2002 and we censored it after a 30-month period for the present analysis. We performed prospective surveillance of bloodstream infections (CDC definitions) [7]. Systematic screening for MRSA, *Candida* and vancomycin-resistant enterococci (VRE) was performed at entry, weekly thereafter and at discharge. The tips of all removed catheters were send for culture. Infections occurring later than 48 h after admission or within 48 h of discharge were considered as ICU acquired.

Infection control consisted in the application of most measures included in the concept of standard and isolation precautions [8]. Hand rub with alcohol-based (65 °) solutions was strongly encouraged as procedure of choice for hand hygiene, and was available in wall-dispensers located at room entrances (Fig. 1) [9]. All patients, including those requiring contact precautions, were housed according to the available place and to match to nurse workforce, except (1) those requiring air or droplet isolation upon admission, (2) those profoundly immunosuppressed and (3) those known as MRSA carriers prior to admission. These 207 patients were systematically admitted to single rooms with negative pressure and were excluded from the present analysis (Fig. 1, beds marked "I"). Infectious risks were computed against the type of bed by weighted ANOVA. Multivariate analysis explored the effect of mechanical ventilation, cardiovascular and renal failure, and the type of bed on the infectious risks by nominal logistic regression.

Results

Over 30 months, 2,522 patients were surveyed, representing 8,811 patient-days. Median (interquartile) length of stay was 1.1 (1.0–3.0) days, and mortality 5.4%. The severity of illness of patients admitted to bay rooms may be viewed as greater on some parameters than that of those admitted to single rooms or in cubicle (Table 1). Approximately 10% were moved from one bed to another, mainly to match the nurse workforce. The respective stay of these patients was assigned to each occupied bed.

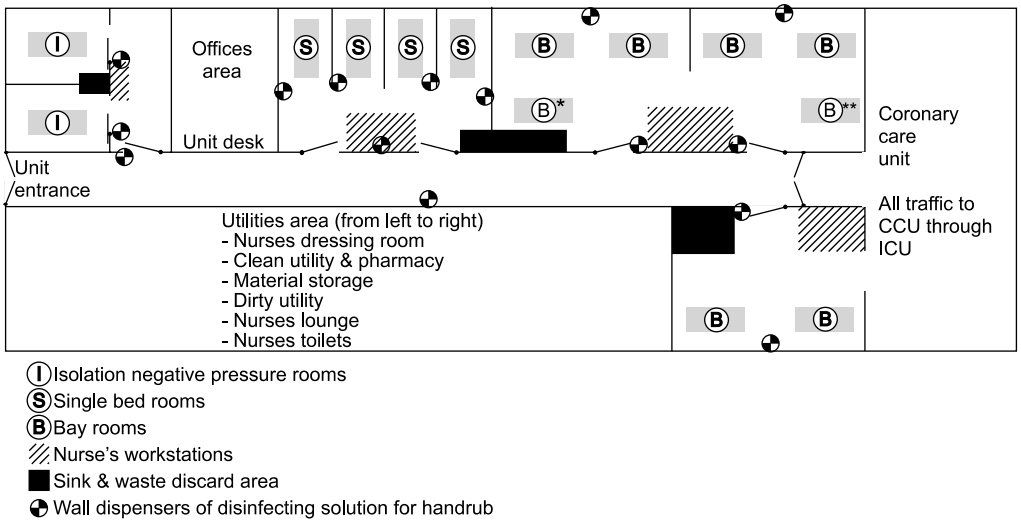

Fig. 1 Floor plan of the ICU of Hôtel-Dieu Hospital, Montreal.
* Bed with highest absolute number and ** bed with the highest incidence-density of positive blood culture. ◓ Wall dispensers for hand-rub solutions

Table 1 Characteristics of the patients

	Bay rooms $n = 903$	Single rooms or cubicles $n = 1619$
Characteristics of the patients		
Patient days	2465	6346
Sex (%)	61% M/39% F	67% M/33% F
Reason for admission		
Post surgery	488 (54%)	1076 (66%)
Medical admissions	415 (46%)	543 (34%)
Age (years) [weighted mean ± SD]	65.1 ± 15.6	64.7 ± 12.4
Length of stay in the same bed (days) [mean ± SD]	2.73 ± 6.92	3.92 ± 3.73
Mechanical ventilation (% of patient days)	567 (23)	2684 (42)*
# of organ failure [weighted mean ± SD]	1.43 ± 0.65	1.29 ± 0.53
Mortality (% of patients)	75 (8.3)	47 (2.9)*
Transfused (% of patient days)	513 (21)	2031 (32)*
Received antibiotics (% of patient days)	1455 (59)	4740 (75)*
Infectious risks as episodes/1000 patients day [mean and 95%CI]		
Bloodstream infections	20.5 [16.9–24.9]	9.4 [6.5–13.5]*
Positive catheter culture	11.3 [8.7–14.7]	2.0 [0.9–4.4]*
MRSA acquisition	4.1 [2.7–6.3]	1.3 [0.5–3.4]*
Pseudomonas spp. acquisition	3.9 [2.5–6.1]	0.7 [0.2–2.4]*
Candida spp. colonization	38.4 [33.3–44.1]	13.8 [10.2–18.6]*

*$p < 0.001$ single room versus bay room

A total of 157 positive blood cultures were retrieved over 30 months. The incidence density of bloodstream infections and of positive catheter cultures were significantly higher in patients admitted to beds located in bay rooms than in those admitted to single rooms or cubicles (Table 1). The bed with the highest number of positive blood cultures ($n = 23$; marked * on Fig. 1) was adjacent to the sink and waste discard area of the large bay room and that with the highest blood culture incidence density (33/1,000 patient-days; marked ** on Fig. 1) was adjacent to the large bay room door (marked ** on Fig. 1). However, bed-to-bed comparison did not reach statistical significance. The ICU acquisitions of MRSA, of *Pseudomonas* spp. and of *Candida* spp. were higher in patients admitted to beds located in bay rooms (Table 1).

The MRSA rate in admitted patients was 1.1% over the observation period, with monthly variations from 0% to 2.5%. The rate of ICU MRSA acquisition was 2.4%, and 0.6% of MRSA-positive patients were found to be MRSA-negative on discharge.

Table 2 Predictors of MRSA, *Pseudomonas* and *Candida* infections

	Univariate analysis Effect [OR (95% CI)]	*p* value	Multivariate analysis Effect [OR (95% CI)]	*p* value
Risk of MRSA acquisition				
Outcome (ICU dead)	1.41 (0.76–2.64)	NS	1.04 (0.57–1.84)	NS
Mechanical ventilation	32 (4–233)	< 0.001	0.82 (0.58–1.18)	NS
Days with MV (per day)	1.22 (1.14–1.29)	< 0.001	1.28 (1.20–1.36)	< 0.001
Parenteral nutrition	7.19 (1.99–52.7)	< 0.001	2.95 (1.17–7.52)	0.02
Type of bed (single room or cubicles vs. bays)	0.33 (0.11–0.95)	< 0.05	0.65 (0.42–0.98)	< 0.05
Risk of *Pseudomonas* acquisition				
Outcome (ICU dead)	1.89 (1.67–2.13)	< 0.001	1.32 (1.10–1.60)	0.003
Mechanical ventilation	78 (62–97)	< 0.001	10.2 (5.51–21.7)	< 0.001
Days with MV (per day)	1.11 (1.10–1.13)	< 0.001	1.16 (1.15–1.18)	< 0.001
Parenteral nutrition	5.97 (5.88–6.03)	< 0.001	2.25 (1.82–2.77)	< 0.001
Type of bed (single room or cubicles vs. bays)	0.33 (0.28–0.38)	< 0.001	0.61 (0.49–0.67)	0.001
Risk of *Candida* acquisition				
Outcome (ICU dead)	1.73 (1.56–1.93)	0.001	1.02 (0.86–1.20)	NS
Mechanical ventilation	29 (19–45)	< 0.001	13.0 (8.6–20.8)	< 0.001
Days with MV (per day)	1.167 (1.164–1.172)	0.01	1.15 (1.14–1.16)	0.001
Parenteral nutrition	4.45 (4.13–4.48)	< 0.001	3.0 (2.4–3.7)	0.001
Type of bed (single room or cubicles vs. bays)	0.54 (0.49–0.60)	< 0.001	0.75 (0.60–0.97)	< 0.03

MRSA: Methicillin resistant staph aureus; ICU: Intensive care unit; MV: Mechanical ventilation

After adjustment for potential confounding factors (emergency admission, mechanical ventilation, medical/surgical patient), location of patients remained a significant factor associated with reduced MRSA, *Pseudomonas* and *Candida* colonization (Table 2).

Discussion

Our observations explore the potential role of architectural factors in the prevention of nosocomial infections. The relative risk of bloodstream infection, of MRSA, of *Pseudomonas aeruginosa* and of *Candida* spp. acquisition and of catheter-related infections in single rooms or in cubicles versus bay rooms was reduced by 54%, 68% and 82%, respectively. For MRSA, our data confirm those reported by Gastmeier et al. in a multicenter study [10] comparing single- versus bay-room units across Germany: the relative risk presented by Gastmeier et al. was 0.36 between units, very close to the 0.32 value between patients in the same unit of the present cohort.

The prevention of nosocomial infections results from the combination of multiple factors, including those targeted at the reduction of cross-transmission of microorganisms. Our data suggest that environmental factors, rarely explored compared to compliance with other components of a hospital's infection control measures included in standard and isolation precautions, and probably of less crucial importance, should nevertheless be considered [11, 12]. The allocation of patients to the different types of rooms was not randomized, and this should be viewed as a limitation of the interpretation of our observation. We could not rule out potential unidentified confounding factors. However, in single rooms and in cubicles, health care workers were strongly encouraged to use hand-rub solution from wall-dispensers when they passed from one patient to another. In addition, the architectural structure of single rooms or cubicles prevents the sharing of objects such as stethoscopes, electrical or vacuum plugs. In contrast to what was reported by Cepeda et al. on the impact of moving MRSA patients into single rooms after screening or not, we observed a markedly higher acquisition of MRSA in patients housed in bays. Low compliance with hand hygiene and delayed moving of MRSA patients until the results of screening are available may open the door to potentially important unrecognized cross-transmission in wards hyperendemic for MRSA (30–40%) [5, 13, 14, 15].

In conclusion, in an institution where MRSA is not hyperendemic, our data suggest that infection control measures may be more effective in preventing cross-transmission of microorganisms in patients housed in single rooms or cubicles.

References

1. Vincent J (2003) Nosocomial infections in adult intensive-care units. Lancet 361:2068–2077
2. O'Connell NH, Humphreys H (2000) Intensive care unit design and environmental factors in the acquisition of infection. J Hosp Infect 45:255–262
3. Dettenkofer M, Seegers S, Antes G, Motschall E, Schumacher M, Daschner FD (2004) Does the architecture of hospital facilities influence nosocomial infection rates? A systematic review. Infect Control Hosp Epidemiol 25:21–25
4. Vietri N, Dooley D, Davis C, Longfield J, Meier P (2004) The effect of moving to a new hospital, facility on the prevalence of methicillin resistant *Staphylococcus aureus*. Am J Infect Control 32:262–267
5. Cepeda J, Whitehouse T, Cooper B et al (2005) Isolation of patients in single rooms or cohorts to reduce spread of MRSA in intensive-care units: prospective two-centre study. Lancet 365:295–304
6. Cooper BS, Stone SP, Kibbler CC, Cookson BD, Roberts JA, Medley GF, Duckworth G, Lai R, Ebrahim S (2004) Isolation measures in the hospital management of methicillin resistant *Staphylococcus aureus* (MRSA): systematic review of the literature. Br Med J 329:533
7. Garner J, Jarvis W, Emori T, Horan T, Hughes J (1996) CDC definitions for nosocomial infections. In: Olmsted R (ed) APIC infection control and applied epidemiology: principles and practice. Mosby, St. Louis, pp. A1–A20
8. Garner JS, Hospital Infection Control Practices Advisory Committee. Guideline for isolation precautions in hospitals. CDC Bethesda. [http://www.cdc.gov/ncidod/dhqp/gl_isolation.html] accessed 2-13-2007
9. Boyce JM, Pittet D (2002) Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. Society for Healthcare Epidemiology of America/Association for Professionals in Infection Control/Infectious Diseases Society of America. MMWR Recomm Rep 51:1–45
10. Gastmeier P, Schwab F, Geffers C, Ruden H (2004) To isolate or not to isolate? Analysis of data from the German Nosocomial Infection Surveillance System regarding the placement of patients with methicillin-resistant *Staphylococcus aureus* in private rooms in intensive care units. Infect Control Hosp Epidemiol 25:109–113
11. Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, Perneger TV (2000) Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. Lancet 356:1307–1312

12. Lucet JC, Paoletti X, Lolom I, Paugam-Burtz C, Trouillet JL, Timsit JF, Deblangy C, Andremont A, Regnier B (2005) Successful long-term program for controlling methicillin-resistant *Staphylococcus aureus* in intensive care units. Intensive Care Med 31:1051–1057
13. Beovic B, Bufon T, Cizman M, Kolman J, Skerl M (2005) Isolation of patients with MRSA infection. Lancet 365:1304
14. Brun-Buisson C, Girou E (2005) Isolation of patients with MRSA infection. Lancet 365:1303
15. Lessing MPA, Loveland RC (2005) Isolation of patients with MRSA infection. Lancet 365:1303