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Efficacy of an information system addressed to nursing staff for diminishing contaminated blood cultures: a blind clinical trial

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ABSTRACT

Introduction. Evaluate the efficacy of an information system addressed to nursing staff to lower the blood culture contamination rate.

Methods. A blind clinical trial was conducted at Internal Medicine and Emergency Departments during 2011. After following a reeducation program in BC extraction, participants were randomly selected in a 1:1 ratio. Every participant of the experimental group was informed of each worker's individual performance; whereas the control group was only informed of the global results.

Results: A total of 977 blood extractions were performed in 12 months. Blood culture contamination rate was 7.5%. This rate was higher in the Emergency Department than in Internal Medicine (10% vs. 3.8%; *p*=0.001). Factors associated with the higher risk of contamination were, in the univariate analysis, the extraction through a recently implanted blood route and the time of professional experience, while those associated with a lower risk were the extraction in Internal Medicine and through a butterfly needle. On multivariate analysis, extraction through a recently placed access was an independent risk factor for an increased contamination rate (OR 2.29; 95%CI 1.18-4.44, *p*=0.014), while individual information about the blood culture results (OR 0.11; 95%CI 0.023-0.57; *p*=0.008), and more than 9 years of professional experience were associated with fewer contaminations (OR 0.30; 95%CI 0.12-0.77; *p*=0.012). In the intervention group the contamination rate diminished by a 26 %.

Conclusions: Drawing blood cultures through a recently taken peripheral venous access increased their risk of contamination. The intervention informing the nurse staff of the contamination rate is effective to decrease it.

Keywords: contamined blood culture, nursing staff, feedback information

Eficacia de un sistema de información dirigido al personal de enfermería para disminuir la contaminación de los hemocultivos: un ensayo clínico ciego

RESUMEN

Objetivos. Evaluar la eficacia de un sistema de información dirigido al personal de enfermería, en la reducción de la tasa de contaminación de los hemocultivos.

Métodos. Durante el año 2011, se realizó un ensayo clínico en los servicios de Medicina Interna y de Urgencias. Después de seguir un programa de reeducación en la extracción de los hemocultivos, los participantes, fueron aleatorizados en una proporción de 1:1. En el grupo de intervención se informó del porcentaje de hemocultivos contaminados de cada profesional y en el grupo control se aportaba la información del porcentaje global de contaminaciones.

Resultados. Durante un periodo de 12 meses se realizaron 977 extracciones. La tasa de contaminación de los hemocultivos fue del 7,5%. Esta tasa fue mayor en Urgencias que en Medicina Interna (10% versus 3,8%, *p*=0,001). Los factores asociados con mayor riesgo de contaminación fueron, en el análisis univariable: la extracción a través de una vía sanguínea recientemente implantada y el tiempo de experiencia profesional; mientras que los que se asociaron con menor riesgo fueron la extracción en Medicina Interna (versus en Urgencias) y a través de una palomilla.

En el análisis multivariable, la extracción de los hemocultivos de una vía recientemente implantada se relacionó de forma independiente con un incremento de las contaminaciones (OR 2,29, IC 95% 1,18-4,44, *p*=0,014),

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mientras que la información individual sobre los resultados de los hemocultivos (OR 0.11; IC 95% 0,023-0,57; *p*=0,008) y la experiencia profesional mayor de 9 años, lo hizo con menos contaminaciones (OR 0,30, IC 95% 0,12-0,77, *p*=0,012). En el grupo de intervención la tasa de contaminaciones se redujo en un 26%.

Conclusión. La extracción de hemocultivos a través de una vena periférica recientemente implantada aumentó el riesgo de contaminación de los mismos. La intervención informativa a los enfermeros de la tasa de contaminación de los hemocultivos, es eficaz para disminuirla.

Palabras Clave: hemocultivos contaminados, personal de enfermería, información de retroalimentación

INTRODUCTION

Blood culture (BC) is a critical tool for health care professionals as a means to detect dangerous pathogens in the bloodstream [1,2]. However, culture bottle's contamination by bacteria of the patient's skin, staff hands or contaminated fomites is a frequent event during handling. Contamination carries an important human and economic cost [3,4]. Many studies have been performed to identify the cause of contamination. Among the suspected factors are the site of venipuncture, the lack of asepsis at the skin and bottle cap, and the use of a single versus double needle for the bottle inoculation [1,5].

Some studies have highlighted the value of an educational intervention and the implementation of an adequate protocol for BC extraction [4-6]. Contamination has been associated with the lack of utilization of antiseptic fluid use independent of its type, of repeated palpation of the vein, the use of extraction from a non-peripheral vein location and the disinfection of the bottle port. Another study focused on an educational intervention when 3 contamination episodes were attributable to a single blood extractor, finding on multivariate analysis, that only the absence of the educational intervention was an independent variable associated with BC contamination [4].

Given the high contamination rate in our Internal Medicine (IM) and Emergency Departments (ED) (around 8%), we undertook this study to evaluate the efficacy of an educational intervention comparing contamination rates in a group that received feedback on each worker's individual performance vs a group given only information on the global results of the blood cultures contamination.

METHODS

We performed, during 2011, a blind clinical trial to compare contamination rates in a group given feedback on each worker's individual performance vs a group given only feedback on the global performance. It took place in the Internal Medicine and Emergency Departments at Hospital Severo Ochoa, a 450-bed secondary care academic medical center.

The study was approved by the local Ethics Committee and informed consent was obtained before participants were selected for participation in the study. Nurses were randomly selected and paired in the intervention group or in the control group in a 1:1 ratio. It was done by a computer program, stratified by hospital departments, and sampled in blocks of 5. Sealed envelopes provided the results of BC contamination. During the first two months of the study no information was supplied to the participants. Thereafter, the control group received every month by internal mail a report of the number of BCs included in the study till then and the ongoing global contamination percentage. The nurses of the intervention group received not only that information but their individual contamination rate as well. The isolation of a germ was considered as contamination depending on the growth of a particular organism and the patient's clinical condition. Although *Corynebacterium* sp., *Lactobacillus* sp., *Propionibacterium acnes* and *Staphylococcus* coagulase negative were accepted as possible contaminants, these organisms may be true pathogens under certain conditions (for example in the presence of intravascular foreign bodies such as catheters or prosthetic valves). The decision of BC contamination was established by an evaluating committee composed by a microbiologist, an internist and an infectious disease specialist who determined the clinical significance of each isolations. They reviewed also the medical records.

We selected consecutive cultures drawn by the nurses during the study period (paired BC taken from patients in the inpatient unit of IM and the ED). Only extractions by direct venipuncture or when extraction was performed immediately after insertion of the peripheral route were included. We excluded from the analysis: 1) cultures extracted from an old central or peripheral vein; 2) one or more than two extractions for a single patient. The reasons for their exclusion were the higher risk of contamination and to homogenize the sample.

The unit of randomization was the extracting nurse. Every demographic characteristic, employment detail and professional experience time of the nurses as well as every clinical factor of patients proven relevant to a difficult blood extraction was collected. In addition, independently of the assigned group, the nurse sent in each extraction to the laboratory a form in which data about the protocol were collected [hand disinfection, use of gloves, preparation of patient skin and bottle ports, products and methods for disinfection, use of butterfly at the blood drawing, (a butterfly shaped device to handle the needle), if it was a difficult extraction or help by another nurse and if cultures were drawn from a peripheral vein immediately after placement].

Statistical analysis. Experimental and control groups were categorized depending on potential risk factors, including characteristics of each nurse or patient and data of extraction protocol. Descriptive statistics were conducted to characterize the overall study population. Patient-related, nurse-related and extraction-related contamination risk factors were analyzed with multivariate logistic regression (backward stepwise selection) being the dependent variable BC contamination after implementation of the intervention. Variables were tested in a bivariate analyses and considered for inclusion in the final multivariate

model when p was lower than 0.20. All analyses were performed using SPSS package version 20 for MAC (IBM SPSS Statistics).

RESULTS

Baseline nurse characteristics are shown in table 1. Both groups were similar with the exception of age (controls were 2.8 years younger). The Microbiology laboratory received 977 sets of blood cultures, 60.5 % from the ED. One hundred and twenty three were excluded because of rejection criteria mentioned (figure 1).

Sixty four (7.5 %) of the 854 BC included were contaminated (table 2). This rate was significantly higher in the ED than in IM (10% vs. 3.8%; p= 0.001). The percentage of true positive BCs was 6.2% and similar in both departments (7.1% in ED and 5.2% in Internal Medicine; p= 0.267). As 7.5% of BC were contaminated and 6.2% were true positive, the probability a microorganism growing which needed no-treatment was 55% (likelihood that the isolation in the blood culture corresponds to a contaminated blood culture).

We evaluated 600 extractions (second period) for the analysis of the main outcome, excluding the BC that took place in the first 2 months of the study because of the absence of any intervention (first period) (figure 1). The contamination rate was 26% lower in the experimental group (5.7% vs. 7.7%), not being statistically different (p= 0.33). There were no statistically significant differences in the prevalence during the first and the second period (7.3 vs 5.7%; p= 0.46) in the intervention or in the control group (7.3 vs 7.7%; p= 0.84). We noticed a clinically relevant drop in the contamination rate in the experimental group along the study, from 7.2% in the first six months to 3.6% in the last six months, close to the 3% recommended by the American Society of Microbiology.

Experimental and control groups categorized by the potential risk factors are shown in table 3. There were differences in gloves use, butterfly-needle and ethanol use, in the time waited (less than 30 seconds or not), in the preparation of bottle top and in the age of the nurse staff between the control group and the intervention group.

Factors associated significantly to a higher contamination risk on bivariate analysis were the extraction through a recently placed line (versus to direct venipuncture), and having less than 9 years of professional experience, whereas extraction in IM and through a butterfly needle were related to a lower contamination risk (table 4).

We found a lower contamination rate with chlorhexidine that when it was not used, not achieving statistical significance due to the disproportion of sample size, since it was only used in 26% of extractions.

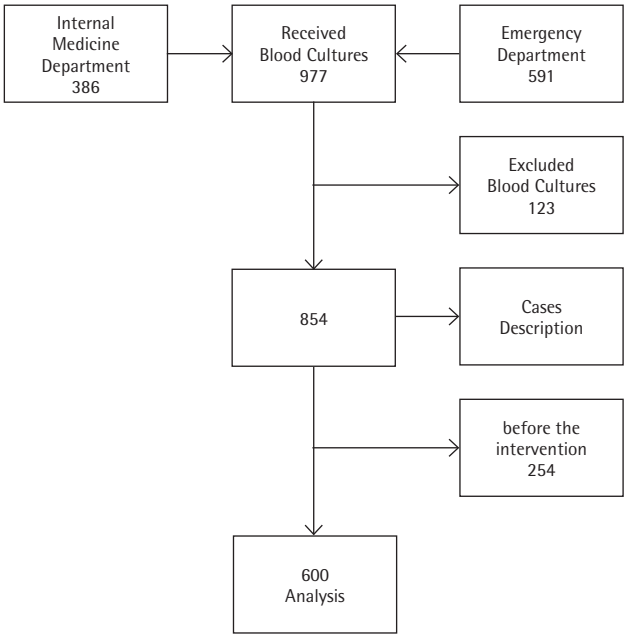

Figure 1 | **Flowchart of the blood cultures before and after of intervention**

Table 1 | **Baseline nurse characteristics.**

	Control (N=25)	Intervention (N=31)	P
Age (years)	34.3	31.5	0.050*
Years of professional experience (mean)	10.4	8.9	0.279
Years of professional experience in the same department (mean)	6.4	5.6	0.363
Males, n (%)	5 (20)	4 (12.9)	0.493
Temporary employment, n (%)	17 (40)	10 (54.8)	0.269
Department			
Internal Medicine, n (%)	11 (44)	19 (61.3)	0.197
Emergency Department, n (%)	14 (56)	12 (38.7)	

Table 2 | **Blood culture results.**

	Number	Percentage
Negative blood cultures	737	86.3%
True positive blood cultures	53	6.2%
Contaminated blood cultures	64	7.5%

On multivariate analysis, the extraction through a recently placed line was an independent risk factor for an increased contamination rate, whereas individual information on the BC results and more than 9 years of professional experience were

Table 3 **Experimental and control groups categorized by the potential risk factors**

Variable	(n)	Intervention	Control	P
Difficult extraction	Yes (119)	56 (21.2)	63 (18.8)	0.453
	No (481)	208 (78.2)	273 (81.2)	
Hemodynamic instability	Yes (66)	31 (11.7)	35 (10.4)	0.606
	No (534)	233 (88.3)	301 (89.6)	
Recently inserted line vs direct venepuncture	Yes (158)	72 (27.3)	84 (25)	0.529
	No (442)	192 (72.7)	252 (75)	
Gloves use	Yes (583)	249 (94.3)	334 (99.4)	0.001*
	No (17)	15 (5.7)	2 (0.6)	
Ethanol use	Yes (400)	193 (73.1)	207(61.6)	0.003*
	No (200)	71(26.9)	129 (38.4)	
Chlorhexidine use	Yes (128)	50 (18.9)	78 (23.2)	0.205
	No (472)	214 (81.1)	258 (76.8)	
Povidone-iodine use	Yes (418)	179 (67.8)	239 (71.1)	0.379
	No (182)	85 (32.2)	97 (28.9)	
Cleansing in concentric circles	Yes (479)	214 (81.4)	265 (78.9)	0.448
	No (120)	49 (18.6)	71 (21.1)	
Waiting 30 seconds	Yes (464)	219 (83)	245 (72.9)	0.004*
	No (136)	45 (17)	91 (27.1)	
Preparation of bottle top	Yes (154)	50 (18.9)	104 (31)	0.001*
	No (446)	214 (81.1)	232 (69)	
Arterial extraction	Yes (37)	19 (7.2)	18 (5.4)	0.352
	No (563)	245 (92.8)	318 (94.6)	
Help by a colleague	Yes (332)	138 (52.3)	194 (57.7)	0.181
	No (268)	126 (47.7)	142 (42.3)	
Butterfly-needle use	Yes (303)	164 (62.1)	139 (41.1)	0.001*
	No (297)	100 (37.9)	197 (58.6)	
Department	Internal M (255)	146 (55.3)	109 (32.4)	0.001*
	Emergency D. (345)	118 (44.7)	227 (67.6)	
Professional experience time	<9 years (299)	130(49.2)	169 (50.3)	0.797
	>9 years (301)	134 (50.8)	167 (49.7)	
Professional experience time in the department	<4.5 years (137)	69 (26.1)	68 (20.2)	0.088
	>4.5 years (463)	195 (73.9)	268 (79.8)	
Age	<31 years (194)	99 (37.5)	95 (28.3)	0.016*
	>31 years (406)	165 (62.5)	241 (71.7)	

significantly associated with fewer contaminations. The individualized knowledge of the culture results was associated with a drop of contamination of 89% (table 5).

The use of butterfly needles for the extraction of blood cultures was the factor that was most related to the reduction of the risk of contamination in the univariate analysis. However, probably, because its use was not very widespread (62.1% in intervention group and 41.1% in control group), its association in multivariate analysis could not be demonstrated.

DISCUSSION

Several strategies have been tried to reduce BC contamination. The most effective measure to reduce it is the availabil-

Table 4 **Univariate analysis of contamination-related factors.**

Variable	(n)	N (%) Contaminated BC	OR (95%CI)	P
Difficult extraction	Yes (119)	10 (8.4)	1.33 (0.63-2.80)	0.448
	No (481)	31 (6.4)	1	
Hemodynamic instability	Yes (66)	7 (10.6)	1.75 (0.74-4.11)	0.197
	No (534)	34 (6.4)	1	
Recently inserted line	Yes (158)	18(11.4)	2.342 (1.23-4.47)	0.008*
	No(442)	23 (5.2)	1	
Gloves use	Yes (583)	41 (7.0)		0.621
	No (17)	0		
Ethanol use	Yes (400)	28 (7.0)	1.08 (0.55-2.14)	0.819
	No (200)	13 (6.5)	1	
Chlorhexidine use	Yes (128)	6 (4.7)	0.611(0.25-1.50)	0.278
	No (472)	35 (7.4)	1	
Povidone-iodine use	Yes (418)	29 (6.9)	1.06 (0.53-2.20)	0.878
	No (182)	12 (6.6)	1	
Cleansing in concentric circles	Yes (479)	35 (7.3)	1.50 (0.62-3.65)	0.371
	No (120)	6 (5.0)	1	
Waiting 30 seconds	Yes (464)	32 (6.9)	1.05 (0.49-2.25)	0.910
	No (136)	9 (6.6)	1	
Preparation of bottle top	Yes (154)	9 (5.8)	0.80 (0.37-1.72)	0.573
	No (446)	31 (7.2)	1	
Arterial extraction	Yes (37)	4 (10.8)	1.72 (0.58-5.13)	0.308
	No (563)	37 (6.6)	1	
Help by a colleague	Yes (332)	28 (8.4)	1.81 (0.92-3.56)	0.084
	No (268)	13 (4.9)	1	
Butterfly-needle use	Yes (303)	12 (4.0)	0.38 (0.19-0.76)	0.005*
	No (297)	29 (9.8)	1	
Department	Internal M (255)	11 (4.3)	0.47 (0.23-0.96)	0.035*
	Emergency D. (345)	30 (8.7)	1	
Professional experience time	<9 years (191)	19 (9.9)	1.94 (1.03-3.68)	0.039*
	>9 years (409)	22 (5.4)	1	
Professional experience time in the department	<4.5 years (210)	19 (9)	1.66 (0.88-3.12)	0.115
	>4.5 years (390)	22 (5.6)	1	
Age	<31 years (299)	21 (7)	1.06 (0.56-2.002)	0.854
	>31 years (301)	30 (6.6)	1	
Intervention group	Intervention (264)	15 (5.7)	0.72 (0.37-1.39)	0.322
	Control (336)	26 (7.7)	1	

BC: blood culture.

Table 5 Multivariate analysis of contamination-related factors

Variable	(n)	ORA (95%CI)	P
Use of recently inserted line	Yes (158)	2.29 (1.18-4.44)	0.014*
	No (442)	1	
Help by a colleague	Yes (332)	0.93 (0.41-2.12)	0.856
	No (268)		
Professional experience time	>9 years (409)	0.30 (0.12-0.77)	0.012*
	<9 years (191)	1	
Intervention group	Intervention (264)	0.11 (0.023-0.567)	0.008*
	Control (336)	1	

ity of an experienced phlebotomy team [7-9]. In small hospitals which lack these teams, like ours, an alternative method could be to register and give individualized and personalized information of the own contamination rate to the nurse staff, as shown by a pilot study by Robert [10], in which contamination was reduced by 50% with this measure. On the other hand, feedback to individuals of their personal rates is a well-known technique to improve workers' performance, and it has been successfully used in other situations, such as the reduction of surgical wound infection [11].

In this study, we have been able to show than individualized information can reduce contamination rate by 89%. A higher contamination rate in the less experienced nurses suggests than an experienced team is the best option. An alternative solution to reduce contamination rates could be the assignment of experienced nurses to the supervision of the extractions and the teaching of a correct technique.

Globally, our BC contamination rate was a 7.5%, higher than the interval reported in other studies (0.6-6.25%) [10].

An important finding is that our contamination rate increases significantly when BCs are drawn from a recently inserted line vs. direct venipuncture. This increased contamination rate had been described in an observational prospective study in a pediatric ED [12]. In this study, contamination rate dropped from 9.1% to 2.8% after changing BC drawing from a recently inserted line to direct venipuncture. Proper disinfection of the extraction site is considered nowadays the most important factor to reduce the contamination rate. Several studies show lower contamination when the skin is treated with chlorhexidine versus povidone-iodine [6, 13-15]. The effect of chlorhexidine is improved by the addition of ethanol [16]. In our study, we found a lower contamination rate with use of chlorhexidine although, not achieving statistical significance due to the disproportion of sample size.

Another important factor is the handling of blood during extraction. We have found factors, related to the contamination rate, which had not been mentioned in the previous literature. One is the use of butterfly needles, in which extracted blood is directly inoculated in culture bottles, avoiding secondary manipulation and reducing significantly the contamination rate in our study. The use of butterfly needles for the extraction of blood cultures was the factor that was most related to the reduction of the risk of contamination in univariate analysis. However, probably, because its use was not very widespread, its association in multivariate analysis could not be demonstrated.

The other factor is the intervention of more than one person in blood drawing, which increased contamination although non-significantly. The intervention of multiple people could be a confounder related to the severity of the condition affecting the patient, but in our study we did not find differences in contamination rate in relation to the clinical state of the patient thereby excluding that possibility. After multivariate analysis, performed to avoid biases owed to differences between departments such as the number of extractions, the antiseptic solutions used, the professional experience time and the clinical care, the only three factors which remained significant for the contamination risk were a personalized information of the own culture results, the extraction through a recently inserted line and having more than 9 years of professional experience.

The main strength of our research was that the information gathered from biomedical research could lead us to determine the causes of excessive contamination in the extraction of blood cultures. The limitation of the study was that we did not include all blood culture extractions performed, especially in the ED, due to difficulties owed to the overload of care. It was not possible to rule out the possible exchange of information between the control and the information group as they did not belong to different units.

We believe that personalized information to nurses drawing BC on their individual results should be implemented and that cultures through previously established lines should be interpreted with caution. The study suggests the usefulness of butterfly needles for the extraction of blood cultures.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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