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Diagnostic value of the blind brush in mechanically ventilated patients with nosocomial pneumonia

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Abstract. *Objectives:* To check on the accuracy of a new protected blind brush (BB) inserted through an endotracheal tube to collect respiratory secretions to be used in the diagnosis of nosocomial pneumonia (NP) in ventilated patients. *Design:* Prospective study of patients who had undergone both BB and plugged telescoping catheter via fiberoptic bronchoscopy (PTC-FB) sample collection sessions. *Setting:* Intensive Care Unit of a referral-based University Hospital. *Patients:* All patients ($n = 37$) mechanically ventilated for more than 3 days with clinical and radiological criteria of NP between July 1990 and March 1991. *Interventions:* Randomized BB and PTC-FB sample collection sessions carried out less than 30 min apart. *Measurements and main results:* The two sampling procedures resulted in similar findings with both cultures either negative or positive and identified the same organism and colonies in 31 patients (83.7%). Agreement was 90% when the patients with right or bilateral pulmonary infiltrates were grouped together and 100% when only the right field was considered. Complications arising from BB sampling were much lower than those from the conventional PTC-FB technique. *Conclusions:* Our results, pending confirmation by other prospective studies, indicate that BB sampling is useful in the diagnosis of NP in ventilated patients with radiological evidence of either right or bilateral pulmonary infiltrates and that it could stand in for PTC-FB in ICU settings where this procedure is not available.

Key words: Plugged telescoping catheter – Fiberoptic bronchoscope – Blind brush catheter – Nosocomial pneumonia

Nosocomial Pneumonia (NP) is the second most common hospital acquired infection and the foremost cause of morbidity and death [1, 2]. Clinical and radiological criteria customarily used to diagnose NP in mechanically ventilated patients, especially for those with preexisting underlying lung disease, are relatively unreliable [3]. Furthermore, cultures grown from conventional tracheal aspirate specimens are of poor diagnosis value due to contamination by microorganisms which often form colonies in the upper airways of patients with endotracheal or tracheostomy tubes in place [4, 5].

Since its introduction by Wimberley et al. [6], the procedure to collect brushing samples of respiratory secretions through a plugged telescoping catheter inserted in a fiberoptic bronchoscope (TPC-FB) has not only proved to be reliable in the etiologic diagnosis of NP but it also protects specimens from upper airway contamination. Quantitative cultures are necessary to avoid false positive results when employing this procedure and a threshold of 10^3 colony-forming units/ml (cfu/ml) will adequately distinguish colonizing organisms from NP infections [6–9]. However, facilities and qualified personnel are required to carry out the FB procedure, both of which are not universally available. This method may also bring about serious complications such as a decrease in the saturation of the arterial blood oxygen (SaO_2) [10].

Torres et al. [11] employed a Metras catheter to guide a TPC without fiberoptic bronchoscopy (FB) to collect specimens from 25 ventilated patients and compared culture results with those prepared from samples obtained by the conventional PTC-FB procedure. The sensitivity of both techniques was 100% while the Metras catheter yielded a 61% and the conventional method a 66% specificity. Gold standard reference methods such as lung biopsies were used to confirm results.

Recently a Blind Brush (BB) protected by a balloon-tipped double-sheathed catheter was put on the market, – which could be useful in the diagnosis of NP in ventilated patients. Preliminary results of a study conducted by Lem et al. [12], suggest that this procedure does circumvent upper airway brush contamination.

The aim of this prospective study was to investigate the value of the new BB sampling method in the diagnosis of NP infections in ventilated patients and compare findings with the conventional PTC-FB technique. Complications arising from the two techniques were also compared.

Material and methods

Patients

All patients ($n = 37$) mechanically ventilated in our intensive care unit (ICU) for over 3 days and suspected of having developed an NP infection between July 1990 and March 1991 were included in this prospective study. Clinical and radiological diagnosis were based on the appearance of a new infiltrate on chest films which physical therapy did not resolve and on the following criteria: fever, leukocytosis or leukopenia and purulent tracheal secretions.

The following information was compiled from case histories: age, admission diagnosis, duration of ventilatory support prior to sampling, broad-spectrum antibiotics administered and location of pulmonary infiltrates (right, left or bilateral). Average age was 34±13 years and duration of mechanical ventilation prior to the clinical or radiological diagnosis of an NP infection was 10±7 days. Of the patients 28 (78%) had been receiving broad-spectrum antibiotics 48 h prior to the collection of bronchial brushing specimens. Admission diagnosis are summarized in Table 1.

Methods

Patients suspected of harboring an NP infection underwent BB and PTC-FB sample collection sessions within the first 48 h following clinical or radiological diagnosis. The two sessions were carried out less than 30 min apart in a randomized sequence to avoid order effect. Wimberley's PTC-FB technique [6] was followed to collect brushing samples from the site visualized in chest films. In cases of bilateral infiltration, specimens were retrieved from the right lung. To avoid brush contamination, the bronchoscopy channel was not employed to apply suction or to administer lidocaine. At 20 min before the FB procedure, the oxygen concentration was increased to 100% and a T-adaptor was attached to the endotracheal tube to avoid air leakage.

The new Blind Brushing procedure (BB) was carried out with a cytology brush protected by a double-sheathed balloon-tipped catheter which was inserted through an endotracheal tube without the need of radiological guidance (Fig. 1). The brush had no distal plug and was connected to a handle assembly by a stainless steel line which passed through the lumen of the interior catheter. The extended catheter length including the balloon was 46.5 cm and was designed to protrude 7 cm beyond the distal tip of the endotracheal tube. This system was devised to avoid upper airway brush contamination and was supplied by HLM Medical INC of Irvine, CA (ACCU-CATH, model PCC 215).

After the unit was pressurized by injecting 6 ml air through a one-way check valve, it was inserted into an endotracheal tube up to the "Y" connector, and then the interior catheter was advanced until the balloon was pushed out of the lumen of the exterior catheter. Next, the cytology brush was advanced through the lumen of the interior catheter. After sampling, the brush was withdrawn through the balloon and the double-sheathed catheter.

During sample recovery, intracranial pressure (ICP) (in patients with ICP catheters in place), heart rate, blood pressure and SaO_2 (by pulse oximetry) were monitored.

Table 1. Diagnosis of the patients

Diagnosis	No. patients	%
Head injury	16	43.2
Polytrauma	4	10.8
Neurosurgery	4	10.8
Cardiovascular surgery	3	8.1
Vasculitis	3	8.1
Hepatic transplant	2	5.4
Sepsis	2	5.4
Burns	1	2.7
Myocardial infarction	1	2.7
Cervical trauma	1	2.7

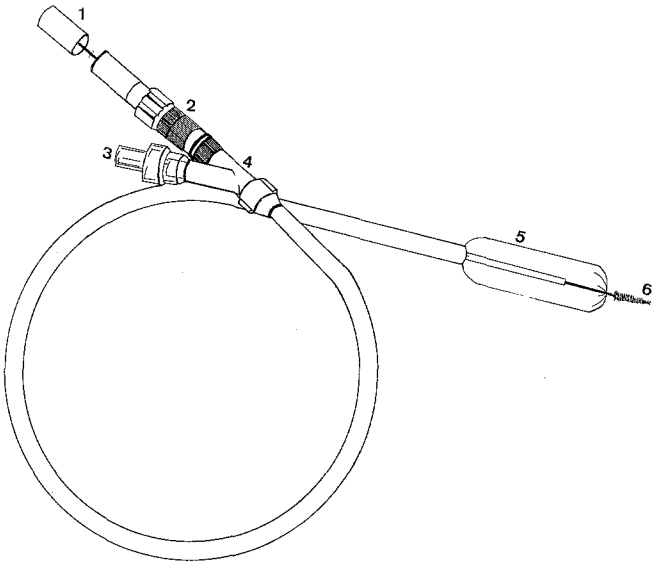

Fig. 1. Blind brush. *1*, Brush handle; *2*, Brush assembly; *3*, Check valve; *4*, Y-connector; *5*, Everted balloon; *6*, Cytology brush

Sample processing

After aseptically cutting the brushes into sterile vials containing 1 ml of sterile saline, they were immediately sent to our microbiology laboratory for processing. Serial dilutions of the samples were prepared and both diluted and undiluted specimens were plated. Plates for aerobic and anaerobic growth were incubated for at least 48 h and those prepared for yeast growth on Sabouraud's glucose agar, were incubated for a period of ten days. Organisms recovered were counted, identified and tested for susceptibility.

Definitions

Cultures prepared from BB and PTC-FB samplings were defined as positive if over 10^3 cfu/ml of a potential pathogen was recovered. Culture specimens yielding under 10^3 cfu/ml were considered to have been contaminated by upper airway organisms, even though gold standard reference methods (lung biopsies) were not performed to confirm this assumption. Cultures prepared from BB-samplings were compared with those obtained by PTC-FB and classified into the following two groups:

Culture agreement (ca): 1. Both cultures were positive and yielded $>10^3$ cfu/ml of the same micro-organism. 2. Both cultures were negative or yielded $<10^3$ cfu/ml.

Culture Disagreement (cd): 1. One culture was positive and yielded $>10^3$ cfu/ml but the other was negative or yielded $<10^3$ cfu/ml. 2. Both cultures were positive and yielded $>10^3$ cfu/ml but the micro-organisms recovered did not coincide either partially or completely.

The percentage of patients belonging to both groups was calculated and each group was correlated with the NP radiological pattern locations.

Serious complications were deemed to have arisen if the SaO_2 level dropped to under 90%, when systolic blood pressure was <90 or >150 mmHg and if an increase 20% greater than the baseline level was recorded for an ICP-monitored patient.

Results

Evaluation of BB and PTC-FB cultures

Cultures of PTC-FB samples recovered from 24 patients (65%) were either negative or yielded colony counts

Table 2. Culture results

	PTC-FB	BB
Patients with positive and $>10^3$ cfu/ml cultures	13	13
Patients with negative or $<10^3$ cfu/ml cultures	24	24

PTC-FB, plugged telescoping catheter via fiberoptic bronchoscopy; BB, blind brush

Table 3. Culture results

P	Group	RX	TBC-FB		BB	
1	CA	L	*P. aeruginosa*	1×10^3	*P. aeruginosa*	1.8×10^3
2	CA	R	*S. aureus*	2×10^2	Negative	
3	CA	R	*S. aureus*	1×10	*S. aureus*	1.5×10^2
4	CD	B	*P. aeruginosa*	1×10^3	*P. aeruginosa*	2.5×10^5
			E. coli	1×10^3		
			K. pneumoniae	1×10^3	*K. pneumoniae*	2.5×10^5
5	CD	L	Negative		*S. aureus*	3×10^3
					P. maltophila	4×10^4
6	CA	R	*K. pneumoniae*	3×10^3	*K. pneumoniae*	8×10^4
7	CA	B	Negative		Negative	
8	CA	B	*A. anitratus*	4×10^4	*A. anitratus*	1×10^3
9	CA	L	*S. aureus*	3×10^3	*S. aureus*	2×10^3
			A. anitratus	3×10^3	*A. anitratus*	1.3×10^4
10	CA	R	Negative		Negative	
11	CA	B	Negative		Negative	
12	CA	R	Negative		*K. pneumoniae*	7×10
					S. aureus	3×10^2
13	CA	B	Negative		Corynebacter	1.5×10
					S. aureus	2×10^2
14	CA	R	Negative		Negative	
15	CA	R	Negative		*A. anitratus*	1.5×10^2
16	CA	B	Negative		Negative	
17	CA	R	Negative		Negative	
18	CA	B	Negative		Negative	
19	CD	B	*S. aureus*	6×10^4	*S. aureus*	1.6×10^5
					A. anitratus	2×10^3
20	CA	R	*S. aureus*	1×10	*S. aureus*	5×10
			K. pneumoniae	8×10	*K. pneumoniae*	2×10
21	CA	B	*S. aureus*	1×10^3	*S. aureus*	1.6×10^4
			H. influenzae	1×10^3	*H. influenzae*	5×10^5
22	CA	B	*S. aureus*	2×10^3	*S. aureus*	3×10^3
					K. pneumoniae	2×10^2
23	CA	B	Negative		Negative	
24	CA	B	Negative		Negative	
25	CA	R	*S. aureus*	1×10^3	*S. aureus*	3×10^3
			P. mirabilis	3×10^3	*P. mirabilis*	1×10^3
26	CA	R	*P. maltophila*	2×10^3	*P. maltophila*	2×10^4
27	CA	R	Negative		Negative	
28	CA	B	Negative		Negative	
29	CA	R	Negative		Negative	
30	CD	B	Candida	1×10^3	Candida	5×10
31	CA	B	Negative		Negative	
32	CA	R	Negative		Negative	
33	CA	B	Negative		Negative	
34	CA	R	*S. aureus*	2×10^4	*S. aureus*	2×10^5
35	CA	R	Negative		Negative	
36	CD	L	*P. vulgaris*	5×10	*P. vulgaris*	3×10^3
37	CD	L	*S. aureus*	1×10^5	*S. aureus*	1×10^2

P, patient number; TPC-FB, telescopic plugged catheter using a conventional fiberoptic bronchoscope; RX, radiologic infiltrate; BB, blind brush culture; R, right; L, left; B, bilateral; CA, culture agreement; CD, culture disagreement

Table 4. Complications

	No. patients	%
TPC-FB		
ICP increase	7	58.3*
SaO_2 decrease	6	16.0
Pulmonary bleeding	5	13.5
Hemodynamic alterations	5	13.5
Pneumothorax	1	2.7
BB		
ICP increase	1	2.7*

* Only 12 of the 16 patients with head injury had ICP monitorized The percentage refers to those 12 patients

$<10^3$ cfu/ml and specimens from 13 subjects (35%) yielded $>10^3$ cfu/ml. The BB samplings obtained from 13 patients (35%) yielded colony counts $>10^3$ cfu/ml while the cultures from 24 cases (65%) were either sterile or colony counts were low (Table 2).

The results of the paired BB and PTC-FB samples agreed in 31 cases (83.7%) but findings differed in the remaining 6 cases (16.3%) (Table 3).

The sample agreement rate was 100% when considering the patients with right pulmonary infiltrates only, and 90% when those with right and left pulmonary infiltrates were grouped together. Of the discordant results 50% involved left pulmonary infiltrates.

Complications

Complications originated by the procedures employed are listed in Table 4.

Discussion

This study proved that cultures prepared from respiratory tract secretions of most mechanically-ventilated patients (83.7%) suspected of having NP recovered via an endotracheal tube by the new BB sampling system have yields similar to those processed from conventional PTC-FB samples. Findings from BB and PTC-FB cultures were in complete agreement when infiltrates were observed in the right lung but were not too reliable when located in the left field. Blind brushing was also found to have a much lower complication rate than the directed PTC technique.

Chastre et al. [7] carried out PTC-FB sampling on the anterior segment of the left lower lobe of 26 ventilated patients who passed away shortly thereafter. Histologic examination and bacteriologic cultures carried out on post-mortem biopsies of this same segment recovered via thoracotomy revealed no evidence of pneumonia in patients who had had culture yields $<10^3$ cfu/ml from plates prepared from PTC-FB samplings. A follow-up study of 147 patients carried out by the same group [8] corroborated the absence of false negative results with the PTC-FB method. Keeping these findings in mind, we assumed in our study that a positive culture with a colony

count $< 10^3$ cfu/ml had the same value as a negative culture.

In contrast, Ha Pham et al. [13] recovered respiratory tract specimens by means of a protected specimen brush (PSB) via bronchoscopy, from 55 ventilated patients suspected of having NP and compared culture results with gold standard reference methods. These authors suggested that cultures prepared from PSB-FB samples should be interpreted cautiously and that the sampling should be repeated when cultures yielded between 10^2 and 10^3 cfu/ml, since such results could correspond to early infection. Histologic reference tests were not carried out in our study so it was not possible for us to ascertain the exact value of cultures with colony counts $< 10^3$ cfu/ml. Hence, 5 of our patients for whom one of the paired samples was considered sterile and the other had a low colony count, could have actually had an early infection (Table 3, patients 2, 12, 13, 15 and 22).

As of late, a number of authors have demonstrated the value of respiratory tract secretions recovered by means other than fiberoptic bronchoscopy for the diagnosis of NP in ventilated patients. Torres et al. [11] compared culture yields of brushing samples retrieved via bronchoscopy with those recovered via the inner channel of a Metras catheter. Of 18 patients with pneumonia, results coincided in 11 cases (61%). These researchers suggested that radiologic guidance was not necessary for catheter insertion. Ha Pham et al. [13] reported that quantitative cultures prepared from samples "blindly" aspirated via a PTC unit had an accuracy similar to that of those obtained by PSB sampling via a fiberoptic bronchoscopy. Their results showed a sensitivity and specificity of 100% and 82.2% for blind PTC and 64.7% and 93.5% for PSB.

In the present study, paired culture findings coincided for all samples recovered from ventilated patients with radiological evidence of right lung NP which, thereby, indicates that the new BB sampling system can be reliably employed in this field. Culture agreement was less when both right and bilateral pulmonary infiltrates were grouped together. In contrast, only 2 of the 5 patients in whom infiltrates were imaged in the left lung were correctly identified by BB sample cultures (Table 3 patients 1 and 9). The low yield for this sub-group is probably due to the fact that a BB catheter is inserted into the main right bronchus due to the anatomical structure of the respiratory tree itself.

Lem et al. [12] have investigated the accuracy of the new BB system in the identification of NP in a group of 16 ventilated patients. Results were compared with a 12 member control group with radiologic evidence of lung infiltrates due to other causes. Conventional tracheal aspirates were obtained from all patients as well. Cultures prepared from BB samplings yielded high colony counts for eight patients of the study group and two control subjects. These authors are of the opinion that, in many instances of NP, sampling of proximal airway secretions may be adequate if endotracheal tube contamination were avoided. Unlike tracheal aspirations, their BB samples were free of endotracheal tube contamination. Their use of quantitative cultures allowed for the identification of the organisms responsible for the pneumonia. Notwithstanding, all the patients with positive culture results had previously received broad-spectrum antibiotics. Furthermore, their study group was comprised of only 16 patients and result accuracy was not checked against gold standard reference methods. Hence, the true number of NP cases as well as to what extent BB sampling actually avoided specimen contamination by upper airway colonizing organisms would be most difficult to ascertain.

The majority of the samples in our study were collected during antibiotic therapy whose administration may lead to lower yields from PTC-FB and BB sample cultures [7, 14–16]. However, antibiotics should not affect concordance between the two techniques.

During the BB session (Table 4) the ICP level rose in one patient, but this was not accompanied by other complications. On the other hand, the performance of bronchoscopy accounted for 7 episodes of ICP increase, 6 of SaO_2 decrease, 5 of pulmonary bleeding, 5 of hemodynamic alterations and 1 of pneumothorax. Other than the patient with pneumothorax who needed pleural drainage, no special measures were required to resolve complications since they all vanished a few minutes after the completion of the procedure. The fact that the complication rate was much lower in other series [5, 9, 11, 14] is probably due to the use of distinctive criteria definitions.

In our opinion, pending confirmation by other prospective studies, the BB sampling method could be a useful tool in the diagnosis of nosocomial pneumonia in ventilated patients. This technique could stand in for the FB procedure, when it is contraindicated due to the poor condition of a patient or in ICU settings where it is not available.

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