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A Prospective Randomized Study Comparing Manual and Wall Suction in the Performance of Bronchoalveolar Lavage

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Abstract

Background: Bronchoalveolar lavage (BAL) may be performed using a hand-held syringe or wall suction. ***Objectives:*** The aim was to study BAL volume and diagnostic yields based on BAL technique. ***Methods:*** A total of 220 consecutive patients undergoing BAL at our center were included. Manual aspiration was performed in 115 patients (group 1), and wall suction (<50 mm Hg of negative pressure) was used in 105 patients (group 2). All bronchoscopies were performed under conscious sedation applying topical anesthesia with lidocaine. Three 50-ml sterile saline aliquots were instilled in all patients. ***Results:*** The mean total amount of fluid recovered was 67 ± 20 ml in group 1 and 55 ± 22 ml in group 2 ($p < 0.001$). More patients in the manual aspiration group met American Thoracic Society criteria (recovery of ≥30% of instilled fluid) for an optimal BAL (81 vs. 59%; $p < 0.001$). The quantity of recovered fluid was also related to BAL location ($p < 0.001$) and radiologic findings ($p = 0.002$). Forty-eight (22%) BALs were diagnostic (23 in group 1 and 25 in group 2), including 37 positive bacterial cultures, 6 positive stains for *Pneumocystis*, and 5 cases of malignancy. No statistically significant difference in diagnostic yield was observed between the two groups. A BAL diagnosis was more likely in patients with certain radiologic ($p = 0.033$) and endoscopic findings ($p = 0.001$). When taking into account all bronchoscopic techniques performed during the procedure (e.g. biopsies, brushing, etc.), bronchoscopy was diagnostic in 37% of patients. ***Conclusions:*** Manual aspiration is superior to wall suction during BAL yielding a larger quantity of aspirate. Diagnostic yields are similar for both techniques.

Introduction

Bronchoalveolar lavage (BAL) is a valuable diagnostic and research tool in patients with respiratory illnesses including interstitial lung disease, infectious diseases, and neoplasms. The volume of fluid instilled during BAL can vary according to an institution's laboratory requirements and the type of testing requested which often includes cytologic assessment, microbiologic analysis and cultures, as well as flow cytometry. Recovery of BAL fluid may be performed using manual aspiration with a handheld syringe or mechanical aspiration using wall suction with a predetermined negative pressure. It is generally assumed that the quality of the procedure is directly linked to the volume of fluid recovered.

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Despite the fact that BAL is the cornerstone of many bronchoscopic procedures, the lack of evidence in favor of a specific technique and discrepancies regarding current recommendations have led to a number of variations in current practice. American Thoracic Society (ATS) guidelines suggest that the minimum total amount of fluid retrieved should be ≥5% of the instilled volume, although optimal sampling should recover >30% [1]. European Respiratory Society (ERS) technical recommendations for BAL do not establish a minimum amount of fluid recovered and do not favor manual aspiration over wall suction. They recommend limiting the negative pressure to 25–100 mm Hg when using wall suction and the trap connection [2]. Finally, Spanish Thoracic Society (SEPAR) guidelines favor manual aspiration and recommend performing BAL before all other endoscopic sampling, including biopsies. Forty percent or more of the instilled aliquots should ideally be recovered [3].

We randomized 220 consecutive patients undergoing BAL at our institution to either wall suction or manual aspiration of BAL fluid and analyzed the variables that determine BAL yields and aspirate volume retrieval.

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Fig. 1. Our BAL setup including extra tubing (a), scout syringe (b), and flow cytometry sample canister (c).

Patients and Methods

The study was approved by the hospital's institutional review board (EO 37/2014_FJD). All patients signed a consent form and were informed of the purpose of this randomized prospective observational study. No patients refused to participate during the 12-month study period (from October 2014 to October 2015). Therefore, all patients undergoing BAL at our center were included.

Bronchoscopy was performed under conscious sedation combining intravenous midazolam and fentanyl, applying topical anesthesia with lidocaine as needed. All procedures were performed by residents in training supervised by one of three senior staff experts in bronchoscopy. Diagnostic Olympus flexible videobronchoscopes with a 2.0-mm working channel were used. Additional endoscopic techniques such as brushing, bronchial and transbronchial biopsies, or blind transbronchial needle aspiration were performed as needed. Whenever additional endoscopic sampling was indicated, BAL was always performed first.

A scout lavage with a 10-ml syringe preceded BAL in order to assess airway wall collapse and identify the best location for sampling. The bronchoscope was systematically wedged in the segment of choice following airway inspection, and three 50-ml sterile saline aliquots were instilled sequentially (fig. 1, 2). Aspiration of BAL fluid was performed after each aliquot, and recovered fluid was segregated in order to preserve the quality of the samples. Patients were randomized to either manual aspiration with a 50-ml syringe and extra tubing applied to the bronchoscope's suction valve (group 1) or wall suction using the suction trap connection applying a maximum of 50 mm Hg of negative pressure (group 2).

Table 1. Selected patient and procedure characteristics

Age, years	61±16
Gender	
Male	146 (66)
Female	74 (34)
Smoking status	
Smokers	75 (35)
Nonsmokers	142 (65)
Antiplatelet therapy	
Yes	35 (16)
No	182 (84)
Platelet count, 10^3/µl	284±134
INR	1.07±0.22
Tolerance	
Well tolerated	208 (94)
Poorly tolerated	12 (6)
Type of BAL	
Manual	115 (52)
Wall suction	105 (48)
Flow cytometry ordered	
Yes	79 (49)
No	83 (51)
Diagnostic BAL	
Yes	48 (22)
No	171 (78)

Values are means ± SD or n (%). INR = International Normalized Ratio.

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Table 2. Indications for bronchoscopy

Infection (including tuberculosis)	84 (38)
Interstitial lung disease or sarcoidosis	46 (20)
Neoplasia	28 (13)
Solitary pulmonary nodule	12 (6)
Hemoptysis	12 (6)
Immunosuppressed patients (including HIV)	13 (6)
Pulmonary infiltrates (nonspecific)	9 (4)
Atelectasis	7 (3)
Other	9 (4)

Values are n (%).

Table 3. Variables influencing BAL volume yields

Variable	p value
Type of aspiration	<0.001
BAL location	<0.001
Radiologic findings	<0.002
Endoscopic findings	0.25
Smoking status	0.19
Anticoagulation	0.32
Antiplatelet therapy	0.82
Age	0.72
Sex	0.73

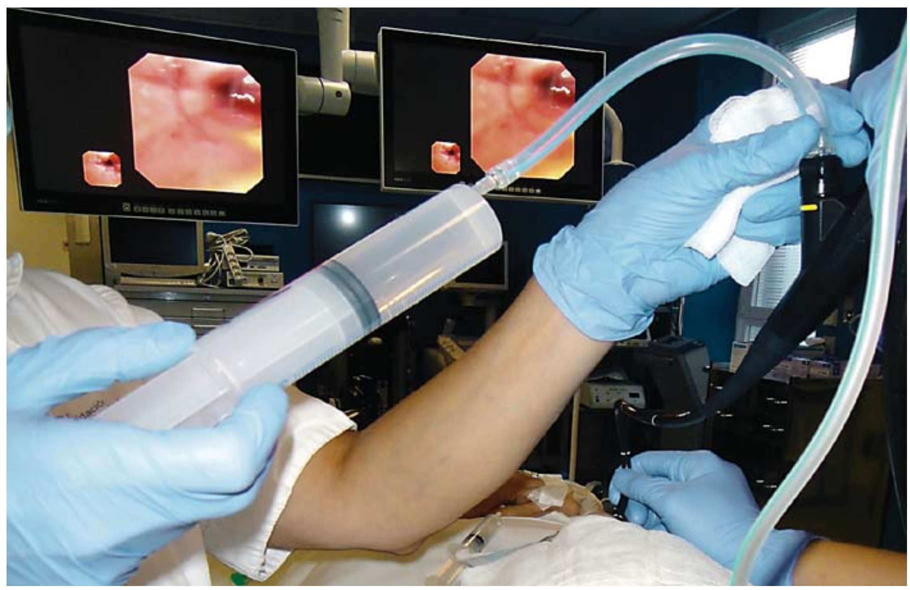

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Fig. 2. Instillation of BAL aliquot using extra tubing. The same tubing and 50-ml syringe are used for manual aspiration of the sample.

Airway collapse was avoided whenever possible by the operator in charge of aspirating the material, either a trained nurse in group 1 or the endoscopist in group 2, by limiting the negative pressure applied. Microbiology, cytology, and flow cytometry studies were performed as needed.

An interim analysis showing a clear difference in volume retrieval with manual aspiration but no statistically significant difference in diagnostic yield led to a protocol deviation after 150 procedures. Patients requiring flow cytometric analysis were assigned to group 1 in order to guarantee that enough material was available for additional testing.

Statistical Analysis

Statistical analysis was performed by a research institute-affiliated statistician with no relation to the hospital's pulmonary department or the study investigators using R software version 3.1.2. Qualitative variables are reported with frequencies and percentages and quantitative variables are reported with means and standard deviations (SD) or medians and interquartile ranges. χ^2 analysis was performed for the comparison of both techniques using predetermined cutoffs for exceptional and optimal BAL sampling with 60 and 30% of recovered fluid as defined by ATS and SEPAR guidelines. A p value of ≤0.05 was considered statistically significant. χ^2 analysis was also performed in order to compare diagnostic yields for both techniques and potential group differences for predetermined qualitative variables. Student's t test was used in order to analyze the quantitative variable distribution in both groups. ANOVA was also performed for group comparisons. Fisher's exact test and χ^2 tests were used to study some correlations between predetermined variables and diagnostic yield.

Results

A total of 220 consecutive patients underwent BAL at our institution during the study period; 115 patients were assigned to group 1 and 105 patients to group 2, and 146

Table 4. Radiologic findings and diagnostic yield of BAL (p = 0.03)

Radiologic findings	Diagnostic	Nondiagnostic
Pneumonia	4 (22)	14 (78)
Mass	3 (23)	10 (77)
Infiltrate (nonspecific)	27 (28)	68 (72)
Sarcoidosis[1]	0	5 (100)
Lung nodule	3 (10)	26 (90)
Bronchiectasis	5 (50)	5 (50)
Normal CT	1 (10)	9 (90)
Atelectasis	3 (33)	6 (67)
Interstitial lung disease	2 (7)	28 (93)

Values are n (%). [1] BAL was never considered by itself diagnostic of sarcoidosis, although flow cytometry findings were often considered supportive of the diagnosis.

Table 5. Endoscopic findings and diagnostic success of BAL (p = 0.001)

Endoscopic findings	Diagnostic	Nondiagnostic
Normal airway	26 (16)	138 (84)
Purulent secretions	7 (29)	17 (71)
Malacia	1 (33)	2 (67)
Blood	4 (80)	1 (20)
Erythema	5 (56)	4 (44)
Secretions	4 (40)	6 (60)
Other	1 (25)	3 (75)

Values are n (%).

patients were male and 74 were female. Thirty-four percent were active smokers and 16% were receiving antiplatelet therapy. Few patients were anticoagulated at the time of bronchoscopy (8.8%), and all had an International Normalized Ratio <1.5 at the time of the procedure. There were no significant differences in patient characteristics, indication for bronchoscopy, age, gender, or radiologic findings between the groups, except that antiplatelet therapy was more common in group 1 patients (p = 0.01). Indications for bronchoscopy and endoscopic findings are detailed in tables 1 and 2.

The mean total amount of fluid recovered was 67 ± 20 ml in group 1 and 55 ± 22 ml in group 2 (p < 0.001). More patients in the manual aspiration group met ATS criteria (recovery of ≥30% of instilled fluid) for an optimal BAL (81% in group 1 vs. 59% in group 2; p < 0.001), but the proportion of BALs yielding ≥60% of the instilled volume was similar (13% in group 1 vs. 10.5% in group 2; p = 0.70). The quantity of recovered fluid was also related to BAL location (p < 0.001) and radiologic findings (p = 0.002). BAL yields were significantly larger for procedures performed in the middle lobe (69 ± 21 ml) and lingula (70 ± 21 ml) than for other locations (table 3).

BAL yields by radiologic findings are summarized in table 4, and the correlations between endoscopic findings and BAL results are outlined in table 5. Forty-eight BALs (22%) were diagnostic (23 in group 1 and 25 in group 2), including 37 positive bacterial cultures, 6 positive stains for *Pneumocystis*, and 5 cases of malignancy. No statistically significant difference in diagnostic yield was observed between the two groups. A BAL diagnosis was more likely in patients with certain radiologic (p = 0.033) and endoscopic findings (p = 0.001). When taking into account all bronchoscopic techniques performed during the procedure (e.g. biopsies, brushing, etc.), bronchoscopy was diagnostic in 37% of patients.

Discussion

BAL was first described as a research tool in 1974 [4]. It has since become a staple of bronchoscopic airway sampling. Unfortunately, BAL technique varies despite a call by medical societies to standardize the procedure [5]. Current clinical practice includes the use of wall suction following instillation of varying amounts and aliquots of saline, but also manual aspiration with a hand-held syringe. We found that hand-held syringe aspiration is superior to wall suction and that it increases the likelihood of performing an optimal BAL meeting ATS criteria. This was a key finding of the study because continuous wall suction appears to be the technique most commonly used in bronchoscopy [6]. While the volume difference in our study did not appear to influence the diagnostic yield of BAL, other studies have shown that BAL volumes correlate with diagnostic success [7]. Furthermore, the growing demand placed by sample processing, including cultures, flow cytometry, and cytological analysis, should prompt optimizing BAL fluid return and, therefore, favors the manual aspiration technique as the best method to perform BAL. Use of a tube extension during manual aspiration has been shown in a multicenter randomized trial to improve sample retrieval [7]. This method, which we use routinely in our bronchoscopy suite, has also been associated with improved diagnostic yields of BAL.

A recently published retrospective pediatric bronchoscopy study supports our findings. The study found that manual aspiration was superior to wall suction in the performance of BAL in children [8]. In that review of over 500 procedures, children in the hand-held syringe group had a 7% higher volume return (95% CI 3.4–11.0; $p < 0.001$) from BAL and 3-fold higher odds (95% CI 1.5–8.6; $p = 0.002$) of undergoing a technically acceptable procedure, despite the fact that wall suction was the preferred BAL technique in more than 2/3 of the children. Similar findings were obtained in an animal study using adult rhesus macaques [9].

A recent publication considering standardization of BAL briefly touched upon the issue of negative pressure, suggesting that it should be kept below 100 mm Hg, but considered both hand-held and wall suction acceptable as long as airway collapse was taken into account [10]. In that publication, a 5% return was considered the minimum amount needed to achieve alveolar sampling, but the authors failed to quantify an optimal aspirate. Current recommendations vary from 'gentle' aspiration of fluid using a hand-held syringe, advocated by an American cooperative study, to the avoidance of visible airway collapse using low wall suction pressure recommended by both the ERS in its 1999 guidelines (25–100 mm Hg) and the ATS in 2012 (<100 mm Hg) [1, 11, 12].

A recently published study did not find significant differences between both BAL methods [13]. In that prospective study, 100 ml of normal saline was instilled in 4 aliquots during BAL, and the percentage of volume return was then calculated. Both the amount of saline instilled and the sample size (66 patients) were smaller than ours, potentially accounting for the inconclusive results. There was no significant difference in the percentage of volume returned or the quality of the aspirate between the two methods. As in our study, a greater return was found in BAL performed in the right middle lobe ($p = 0.002$). The authors concluded that no significant benefit could be attributed to either BAL method in terms of volume, microbiological or diagnostic yields.

It is unclear why manual suction with a hand-held syringe was superior to wall suction in our study, since fluid dynamics during BAL are complex [14]. However, avoidance of airway collapse is probably a key element. We believe that the hand-held syringe method provides better feedback to the operator regarding the amount of negative pressure applied at any given moment during BAL [15]. Changes in negative pressure are also more abrupt with the bronchoscope's suction valve than with a hand-held syringe leading to more airway trauma, bleeding, and airway collapse with this method. Progressive negative pressure adjustments during BAL based on the volume recovered may improve yields with wall suction, but in our experience this is not common practice [16].

In our study, patient age did not correlate with BAL fluid return, as it did in a study by Olsen et al. [16], but BAL location and certain radiologic findings were associated with improved yields. The former is not surprising for it is a well-known fact concerning BAL sampling of the airways that the middle lobe and lingula yield the best returns, but the latter provides further insight into the limitations of BAL in certain clinical settings. Patients with atelectasis had the lowest returns with a mean of 46.4 ± 20.7 ml recovered, while patients with a normal CT scan and those with suspected sarcoidosis or interstitial lung disease had better returns with means consistently above 70 ml. Interestingly, endoscopic findings conditioned BAL diagnostic yields. A diagnostic BAL was less likely in patients with a normal airway (16%) than in those with abnormal mucosa (55%), secretions, or blood in the airway (80%) at the time of bronchoscopy ($p = 0.001$). Radiologic findings were a weak but statistically significant predictor of BAL diagnostic yields ($p < 0.05$).

Conclusion

Our study provides evidence favoring manual aspiration with a hand-held syringe of BAL fluid instead of wall suction, and it provides further evidence supporting the use of tube extensions when performing this common bronchoscopic procedure. While diagnostic yields did not vary, any future attempts seeking to standardize BAL techniques should take into account data from randomized studies. It is in this context that the results of the current study should be interpreted.

Financial Disclosure and Conflicts of Interest

The authors report that there are no conflicts of interest.

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