Original Articles

Value of preoperative spirometry to predict postoperative pulmonary complications

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In order to determine the incidence of postoperative pulmonary complications (POPC) and the value of preoperative spirometry to predict pulmonary complications after upper abdominal surgery, 24 women and 36 men (total 60 patients) were studied prospectively (mean age 48·3 years). On the day before the operation and for 15 days after the operation, each patients's respiratory status was assessed by clinical examination, chest radiography, spirometry and blood gas analysis, and patients were monitored for pulmonary complications by a chest physician and a surgeon independently. In this study, postoperative pulmonary complications developed in 21 (35%) patients (pneumonia in 10 patients, bronchitis in nine patients, atelectasis in one patient, pulmonary embolism in one patient). Of 31 patients with abnormal preoperative spirometry, 14 (45·2%) patients showed complications, whereas among 29 patients with normal preoperative spirometry, 7 (24·1%) patients showed complications ($P<0·05$). The incidence of POPC was higher in patients with advanced age, smoking, preoperative abnormal findings obtained from physical examination of the chest, higher ASA class and longer duration of operation. The sensitivity (0·76) and specificity (0·79) of abnormal preoperative findings obtained from physical examination to predict POPC were higher than abnormal preoperative spirometry (0·67 and 0·56 retrospectively). There was no significant difference between patients with and without pulmonary complications in regard to weight, serum albumin, type of incision, incidence of abnormal preoperative blood gases and duration of postoperative hospital stay. We conclude that POPC is still a serious cause of postoperative morbidity. Multiple risk factors include preoperative abnormal spirometry responsible for development of POPC. If used alone, spirometry has limited clinical value as a screening test to predict POPC after upper abdominal surgery.

Introduction

Pulmonary complications are important causes of postoperative morbidity and mortality (1). In studies conducted over the past 60 yr, reported incidence of postoperative pulmonary complications (POPC) has varied between 5–70%, the highest rates were for upper abdominal and thoracic procedures (2–4). Despite many advances in medical and surgical practice, the incidence of POPC has not changed appreciably over the past 35 yr (5).

The need for a screen test to identify preoperatively the patients at risk has been emphasized since 1930 (6). In the 1960s, several studies concluded that: spirometric tests were more sensitive than medical

history and physical examination for detecting lung diseases; patients with abnormal preoperative spirometry had a higher risk for POPC; and patients with abnormal spirometry benefit from preoperative respiratory therapy (2,7,8). However, recent studies have reported that spirometric tests have a little clinical usefulness for detecting and preventing POPC (9–13). Due to great differences in the methodology of these studies, it is difficult to compare their results (4,14–16). Consequently, some of the controversies in this area result in confusion about the role of preoperative spirometry to detect POPC.

This study aimed to determine the incidence of POPC after upper abdominal surgery and the value of preoperative spirometry to predict POPC.

Material and Methods

Sixty adult patients referred to the Department of General Surgery at Çukurova University Balcalı

Hospital for elective upper abdominal surgery were studied prospectively for a 7-month period. On the day before surgery and for 15 days after surgery, patients were investigated and monitored independently by researchers from the Departments of Chest Diseases and General Surgery. The Balcalı Hospital Ethics Committee for Research on Human Subjects approved the study protocol and each patient's consent was sought before entering the study.

Preoperative respiratory status of all patients was assessed by clinical examination, sputum culture, ECG, chest radiography, spirometry and blood gas analysis. History of past respiratory disease and smoking habit of each patient were noted. Blood samples were obtained for measurement of white cell count, serum total protein and albumin on the day before operation and the results were recorded. Patients were evaluated for their operative risks according to American Society of Anesthesiologist (ASA) class, and preoperative respiratory regimen (bronchodilatator and incentive spirometry) applied (17). The Department of General Surgery was not informed on the data from clinical findings, spirometry, blood gases and ASA classification obtained by the Department of Chest Diseases. Consequently, the final decision of the Department of General Surgery regarding operation was based on findings from clinical examination obtained by two surgeons, chest radiography and blood white cell count alone, as done in their routine practice. None of the patients in the study were excluded from investigation because of respiratory findings obtained by medical history, physical examination and spirometric tests results. During the operation, name and duration of surgical procedures, and type of incision were recorded. After the operation, patients were monitored daily for 15 days by clinical examination. The tests performed preoperatively, were repeated on alternate postoperative days. During this period, mobilization time after operation, postoperative respiratory regimen and pain treatment applied for each patient were recorded. Each patient was examined and monitored for pulmonary complications developed in this period and results recorded.

In this study, postoperative pulmonary complications were classified as pneumonia (diagnosed if the patient had a fever higher than 38·5°C, purulent sputum, positive blood and/or sputum culture, leucocytosis, as well as clinical and/or radiological evidence of consolidation that was not present before surgery); bronchitis (diagnosed if dyspnoea, purulan sputum, wheezing, rhonchus developed in a stable patient preoperatively); atelectasis (diagnosed if the patient

had clinical and radiologic evidence of collapse); and pulmonary embolism (diagnosed if the patient had tachypnoea, chest pain, dyspnoea, signs of chest radiography and deterioration of blood gases).

Spirometric tests were performed by dry rolling spirometry (Vitalograph PFT II Plus) in the sitting position between 8–10 a.m. Forced expiratory manoeuvre was repeated three times and appropriate manoeuvres according to the American Thoracic Society (ATS) criteria were selected (18). The data of the European Community for Coal and Steel (ECCS) were used as a reference for normal values. Vital capacity (VC), forced vital capacity (FVC), forced expiratory volume during the first second of FVC (FEV_1), FEV_1/FVC, mean forced expiratory flow during the middle of the FVC (FEF 25–75%) and maximum voluntary ventilation (MVV) were measured and the results of these tests were stated as percent of predicted values. Abnormal spirometric test was defined using 95% confidence limits. 'Patients with abnormal spirometry' were those patients with one or more abnormal tests.

Arterial blood samples were obtained anaerobically in a heparinized syringe (supine position) with the patient breathing room air at rest. Blood gas determination including PaO_2, $PaCO_2$ and pH were performed using a pH/blood gas analyser NVL-995. Patients with PaO_2 below 80 mmHg and/or $PaCO_2$ over 45 mmHg were defined as 'patients with abnormal blood gas'.

Patients with respiratory symptoms (cough, sputum, dyspnoea, wheezing) were defined preoperatively as 'symptomatic patients'. Patients with one or more abnormal findings from physical examination of the chest (orthopnoea, increase or decrease of tactile fremitus, dullness, crackles or rhonchus) preoperatively were defined as 'patients with abnormal findings of physical examination'.

The data of this study were analysed by the SPSSX statistical package at Çukurova University Computer Centre. Student's t-test and chi-squared test—when necessary, Fisher's exact test—were used for the comparison of group means and proportions respectively. A P-value of less than 0·05 was assumed as significant.

Results

Data on 60 patients planned for upper abdominal surgery (24 female and 36 male) were analysed. Some characteristics of patients are shown in Table 1. Thirty-one (51·6%) patients had abnormal preoperative spirometry, 17 patients had obstructive, nine had restrictive and five had combined functional defects.

Table 1 Patients' characteristics

Patient number	60
Male:female ratio	24:36
Age (years)	
Mean ± SD	48·3 ± 14·9
(range)	(16–79)
Weight (kg)	
Mean ± SD	64·1 ± 9·2
(range)	(35–86)
Smokers	21 (35%)
Preoperative respiratory symptoms (+)	13 (21·7%)
Preoperative findings from physical examination of the chest (+)	24 (40%)
Preoperative abnormal blood gases (+)	12 (20%)
Preoperative abnormal spirometry (+)	31 (51·6%)
Obstructive	17 (28·3%)
Restrictive	9 (15%)
Combine	5 (8·3%)

Values given as number of patients (% of total) unless otherwise indicated.

Actual and percent of predicted values of preoperative spirometric tests of patients are shown in Table 2. Eighteen (30%) of all patients studied had FEV_1 values of less than 70% of FVC. Twelve (20%) patients had abnormal preoperative blood gases (10 patients had hypoxaemia, two had hypoxaemia and hypercapnia). No patient had bronchodilator and incentive spirometry treatment in the preoperative period.

Indications for upper abdominal surgery of 60 patients are shown in Table 3. After premedication with meperidine hydrochloride (1 mg kg^{-1}) and atropine sulphate (0·5 mg), all patients received gen-

Table 3 Indications of surgery in patients

Disease	No	(%)
Intra-abdominal mass	19	31·7
Chronic cholecystitis	13	21·7
Obstructive jaundice	11	18·3
Hydatid disease of liver	6	10·0
Duodenal ulcer	6	10·0
Incisional hernia	3	5·0
Liver malignity	2	3·3
Total	60	100·0

eral anaesthesia (induced with pentothal and succinyl choline, endotracheal intubation, muscle relaxation with pancuronium bromide, halothane N_2O_2 inhalation with mechanical ventilation). The mean duration of an operation was 101·3 min (range 90–195 min).

It is routine practice of the Department of General Surgery to start regular treatment with an empiric antibiotic with broad spectrum and a single dose analgesic (dipyrone amp 0·5 mg day^{-1} and/or pethidine HCL 100 mg day^{-1}) postoperatively for all patients. On the first postoperative day, chest percussion lasting for 5–10 min was applied by a surgeon routinely to all patients. No patient had any other postoperative respiratory regimen. Mobilization time after operation was 12 h for 11 (18·3%) patients, 24 h for 28 (46·7%) patients, 2 days for 17 (28·3%) patients and 3 or more days for four (6·7%) patients (mean ± SD = 1·36 ± 0·93 days).

Table 2 Actual and % predicted values of preoperative spirometric tests of patients with and without abnormal spirometry

Spirometric tests	Patients with normal spirometry ($n=29$)	Patients with abnormal spirometry				Total patients ($n=60$)
		Obstructive ($n=17$)	Restrictive ($n=9$)	Combined ($n=5$)	Total ($n=31$)	
VC (l)	2·9 ± 0·9	3·3 ± 1·2	1·6 ± 0·7	1·4 ± 0·6	2·5 ± 1·3	2·7 ± 1·2
VC (% predicted)	98·7 ± 21·2	98·2 ± 26·2	46 ± 14·8	44·8 ± 12·5	74·4 ± 34	86·2 ± 30·8
FVC (l)	3·0 ± 1·0	2·7 ± 0·9	1·7 ± 0·7	1·6 ± 0·6	2·2 ± 0·9	2·6 ± 1
FVC (% predicted)	105·6 ± 19·9	94·6 ± 28·8	48·3 ± 12·3	49·4 ± 13·5	73·9 ± 33·4	89·2 ± 31·2
FEV_1 (l)	2·4 ± 0·8	1·5 ± 0·7	1·4 ± 0·7	0·9 ± 0·3	1·4 ± 0·7	1·9 ± 0·9
FEV_1 (% predicted)	101·3 ± 17	64·8 ± 22·9	48·4 ± 13·1	37·6 ± 14·8	55·6 ± 21·7	77·7 ± 30·1
FEV_1/FVC (%)	79·9 ± 4·5	57·6 ± 15·2	82 ± 7·1	61·4 ± 10·2	65·3 ± 16·4	72·8 ± 18·7
FEV_1/FVC (% predicted)	96·3 ± 11·6	79·9 ± 49·9	99·9 ± 8·6	65·7 ± 10·2	77·4 ± 18·2	83·7 ± 21·9
FEF 25–75% (l s^{-1})	2·5 ± 0·8	1·1 ± 0·7	1·5 ± 1·1	0·6 ± 0·4	1·1 ± 0·9	1·8 ± 1·1
FEF 25–75 (% predicted	83·4 ± 21	35·2 ± 17·2	41·8 ± 18·3	23·2 ± 12·1	35·2 ± 17·5	58·5 ± 30·9
MVV (l)	92·6 ± 26·5	57·4 ± 26·3	53 ± 25·2	35·4 ± 13·3	52·6 ± 25	71·9 ± 32·5
MVV (% predicted)	89·2 ± 14·6	52·3 ± 18·9	47·3 ± 12·4	33·4 ± 11·1	47·8 ± 17·1	67·8 ± 26·2

Values given as mean ± SD. VC, vital capacity; FVC, functional vital capacity; FEV_1, forced expiratory volume in 1 s; FEF 25–75%, mean forced expiratory flow during the middle of the FVC; MVV, maximum voluntary ventilation.

Table 4 Clinical and laboratory characteristics of patients with and without postoperative pulmonary complication (POPC)

Characteristics	POPC (+) (n=21)	POPC (−) (n=39)	P-value
Age (years)	55·5 ± 10·3	44·3 ± 15·6	<0·01
Male:female ratio	11:10	13:26	n.s.
Height (cm)	163 ± 6·9	163·9 ± 8·8	n.s.
Weight (kg)	62·7 ± 8·9	64·8 ± 9·5	n.s.
Total protein (g dl^{-1})	6·7 ± 0·8	6·9 ± 0·9	n.s.
Albumin (g dl^{-1})	3·8 ± 1	3·9 ± 0·6	n.s.
Preoperative spirometry			
VC (% predicted)	80·7 ± 31·2	89·1 ± 30·6	n.s.
FVC (% predicted)	83·7 ± 30·8	92·2 ± 31·4	n.s.
FEV_1 (% predicted)	68·9 ± 29	82·5 ± 29·8	0·09
FEV_1/FVC (% predicted)	78·7 ± 22·1	86·4 ± 21·6	n.s.
FEF 25–75 (% predicted)	45·5 ± 26·2	65·4 ± 31·3	<0·05
MVV (% predicted)	58·2 ± 24·5	73 ± 25·9	<0·05
FEV_1 values			
<1·25 l	8 (50%)	8 (50%)	0·07
>1·25 l	·13 (29·5%)	31 (70·5%)	
<50% predicted	8 (50%)	8 (50%)	0·07
>50% Predicted	13 (29·5%)	31 (70·5%)	
FEV_1/FVC (%)			
<50	3 (37·5%)	5 (62·5%)	n.s.
>50	18 (34·6%)	34 (65·4%)	
Type of incision			
Subcostal	3 (25%)	9 (75%)	n.s.
Median	10 (40%)	15 (60%)	
Paramedian	8 (34·8%)	15 (65·2%)	

Values given as mean ± SD. VC, vital capacity; FVC, functional vital capacity; FEV_1, forced expiratory volume in 1s, FEF 25–75%, mean forced expiratory flow during the middle of the FVC; MVV, maximum voluntary ventilation; n.s., not significant.

Postoperative pulmonary complications were observed in 21 (35%) patients in the 15 days following upper abdominal surgery. Pneumonia in 10 (16·6%) patients, bronchitis in nine (15%) patients, atelectasis in one (1·7%) patient and pulmonary embolism in one (1·7%) patient developed in the postoperative period. Of the nine patients diagnosed with bronchitis postoperatively, seven were smokers, one had preoperative respiratory symptoms (cough for 5 yr), seven had abnormal physical findings and seven had abnormal preoperative spirometry. Seven patients were evaluated as having exacerbation of bronchitis and two patients as having acute bronchitis. All patients with bronchitis which occurred postoperatively had rhonchus on physical examination of the chest and at least two respiratory symptoms (cough, dyspnoea or purulan sputum). One female patient (55 years, operated on for pancreatic cancer), suffered from sudden onset tachypnoea, dyspnoea, cough and pleuritic chest pain without fever and sputum on the second postoperative day. She was diagnosed with pulmonary embolism using clinical findings, chest X-ray (elevation of right hemidiaphragm and minimal pleural effusion) and Doppler ultrasound (thrombus in right femoral vein). Patients with pneumonia and atelectasis (left lower lobe atelectasis developed in one patient on the first postoperative day) were diagnosed using clinical and radiological findings.

Postoperative respiratory complications and some preoperative patients's characteristics are shown in Table 4. Mean age was higher in patients with complications (55·5 ± 10·3 years) than in patients without complications (44·3 ± 15·6) (P<0·01). Mean height, weight, serum total protein, albumin values and type of incision between patients with and without complications did not show significant differences (P>0·05). Mean values of spirometric tests including VC, FVC and FEV_1/FVC did not show significant differences between two groups, but mean FEV_1, FEF 25–75% and MVV values were lower in patients with complications than in patients without complications. Postoperative pulmonary complications developed

Table 5 Characteristics of patients with and without abnormal preoperative spirometry

Characteristics	Normal spirometry (n=29)	Abnormal spirometry (n=31)	P-value
Age (years)	45·8 ± 14·7	50·6 ± 15	n.s.
Male:female ratio	9:20	15:16	n.s.
Height (cm)	161·7 ± 7·2	164·4 ± 7·7	n.s.
Weight (kg)	64·7 ± 10·6	63 ± 8	n.s.
Total protein (g dl^{-1})	6·9 ± 0·8	6·7 ± 0·9	n.s.
Albumin (g dl^{-1})	4·1 ± 0·7	3·7 ± 0·8	<0·05
Smokers (n %)	9 (31%)	12 (38·7%)	n.s.
ASA class (no %)			
1	11 (37·9%)	7 (22·6%)	n.s.
2	10 (34·5%)	14 (45·2%)	
3	8 (27·6%)	10 (32·2%)	
Preoperative respiratory symptoms (+)	7 (22·6%)	7 (22·5%)	n.s.
Preoperative findings from physical examination (+)	11 (37·9%)	13 (41·9%)	n.s.
Duration of operation (min)	95·2 ± 31·4	106·9 ± 38·5	n.s.
Number of days in hospital from the time of operation	7·6 ± 6·9	6·6 ± 5·5	n.s.
Total number of days in hospital	18·1 ± 11·6	16·1 ± 11·9	n.s.
Mean mobilization time (days)	1·21 ± 0·87	1·56 ± 0·95	n.s.
Postoperative complications			
Pneumonia	4	6	n.s.
Bronchitis	2	7	0·09
Atelectasis	1	0	n.s.
Pulmonary embolism	0	1	n.s.

Values given as mean ± SD; n.s., not significant.

more frequently in patients with lower FEV_1 values (50%) (FEV_1<1·25 1 or FEV_1<50% of predicted) than patients with higher FEV_1 values (29·5%) (*P*=0·07).

Some characteristics of patients with and without abnormal preoperative spirometry are shown in Table 5. Mean serum albumin level was lower in patients with abnormal spirometry (3·9 ± 0·8 g dl^{-1}) than in patients with normal spirometry (4·1 ± 0·7 g dl^{-1}) (*P*<0·05). Mean age, incidence of patients with respiratory symptoms and abnormal findings from physical examination of chest, operative risk according to ASA class, mean operation time, postoperative and overall hospital stay, and mobilization time after operation showed no difference between patients with and without abnormal preoperative spirometry (*P*>0·05). Bronchitis developed more in patients with abnormal preoperative spirometry (22·6%) than patients with normal preoperative spirometry (6·9%) (*P*=0·09).

The relationship between POPC and some possible preoperative risk factors are shown in Table 6. Postoperative pulmonary complication rate was higher (45·2%) in patients with abnormal preoperative spirometry than patients with normal preoperative spirometry (24·1%) (*P*<0·05). In addition to this, of 24 patients with abnormal preoperative findings from physical examination, 16 (66·7%) patients showed complications, whereas of 36 patients with normal findings from physical examination there were five (13·9%) patients with complications (*P*<0·001). Postoperative pulmonary complications developed in three (17·6%) of 17 patients who had abnormal spirometry without respiratory symptoms and abnormal physical findings. Mean operation time and mobilization time after operation was longer in patients with complications than in patients without complications. Postoperative pulmonary complication rate was higher in smoking patients and patients with higher ASA class. There was no significant difference between patients with and without complications regarding presence of abnormal blood gases and respiratory symptoms (*P*>0·05). Mean number of days in hospital from the time of operation and mean total number of days in hospital were not different between patients with and without complications.

The sensitivity and specificity of some preoperative risk factors to predict postoperative pulmonary

Table 6 Relationship between some possible risk factors and postoperative pulmonary complications (POPC)

Risk factors	No.	POPC (+) (n=21)	POPC (−) (n=39)	P-value
Smoking				
Yes	21	10 (47·6%)	11 (52·4%)	0·07
No	39	11 (28·2%)	28 (71·8%)	
Preoperative respiratory symptoms				
Yes	13	6 (46·2%)	7 (53·8%)	n.s.
No	47	15 (31·9%)	32 (68·1%)	
Preoperative abnormal findings from physical examination of the chest				
Yes	24	16 (66·7%)	8 (33·3%)	<0·001
No	36	5 (13·9%)	31 (86·1%)	
Preoperative abnormal spirometry				
Yes	31	14 (45·2%)	17 (54·8%)	<0·05
No	29	7 (24·1%)	22 (75·9%)	
Preoperative abnormal blood gases				
Yes	12	5 (41·7%)	7 (58·3%)	n.s.
No	48	16 (33·3%)	32 (66·7%)	
ASA Class				
1	18	2 (11·1%)	16 (88·9%)	<0·01
2	24	8 (33·3%)	16 (66·6%)	
3	18	11 (61·1%)	7 (28·9%)	
Duration of operation (min)	60	114·3 ± 39·5	94·2 ± 31·3	<0·05
Number of days in hospital from the time of operation	60	7·3 ± 6·3	6·9 ± 6·2	n.s.
Total number of days in hospital	60	19·1 ± 14·2	16 ± 10·1	n.s.
Mobilization time after operation (days)	60	1·81 ± 1·24	1·17 ± 0·61	<0·01

Values given as mean ± SD, or number of patients (% of total); n.s., not significant.

complications are shown in Table 6. Presence of abnormal findings from physical examination of the chest had higher sensitivity (0·76) and specificity (0·79) to predict complications than those of preoperative abnormal spirometry (0·67 and 0·56 respectively).

Discussion

General anaesthesia and surgical procedures affect the respiratory system negatively after upper abdominal operations. Decreased diaphragm activity and ventilatory response causes decreased lung volumes. These may lead to alveolar collapse, atelectasis, early closing of airways, ventilation/perfusion imbalance, decrease in mucus clearance and increase in bacterial colonization. These changes may result in the development of serious pulmonary complications in patients with impaired pulmonary function (19).

In this study, POPC developed in 21 (35%) patients who underwent upper abdominal surgery. The incidence of POPC was reported to be greater than 20–25% in different studies (4,10). It seems that differences in the characteristics of patients studied and the definition of pulmonary complication affect the reported incidence of complications in various studies. Studies reported that respiratory treatment regimens provided in the preoperative and postoperative periods such as intermittent positive pressure breathing, chest physical therapy and incentive spirometry decrease the occurrence of POPC (10,13). The high incidence of POPC observed in this study may be related to the absence of respiratory therapy practice in patients studied.

In 1962, Stein *et al.* published a prospective study and found that the incidence of pulmonary complications was higher in patients with abnormal preoperative spirometry (70%) than in patients with normal spirometry (3%) (7). Latimer *et al.* and Collins *et al.* found abnormal spirometry (FEV_1 and FVC) to be a good predictor of POPC after surgery (2,8). Grover *et al.* reported an operative mortality of 11·7% for patients with an FEV_1 of less than 1·25 l compared with 3·8% for those with an FEV_1 of greater than 1·25 l in cardiac surgery practice (20). A recent study by Kroenka *et al.* on patients with

abnormal spirometry (FEV_1 <50% of predicted) supports the concept that abnormal lung function may be associated with higher incidence of POPC (21). These studies suggest the usefulness of a routine request for spirometry as a screening test to predict POPC. Other studies of upper abdominal surgery suggest that routine preoperative spirometry does not help identify patients in whom pulmonary complications are highly likely to develop (9-13). These studies showed that historical data and findings from physical examination of the chest are more sensitive to detect lung pathology than spirometric tests.

This study found that POPC incidence was higher in patients with abnormal preoperative spirometry (45·2%) than in patients with normal preoperative spirometry (21·4%) (P=0·04). In addition to this, POPC developed more frequently in patients with lower FEV_1 (FEV_1<1·25 l or <50% of predicted).

In this study, definition and diagnosis of POPC, age (48 ± 1·5 years), prevalence of smoking (30%), preoperative FEV_1 (78% ± 30% of predicted) and duration of operation (101·3 ± 35·4 min) of patients studied were different from patients in other studies. Celli *et al.* studied 172 patients who had different types of respiratory therapies, surgical operations (upper and lower abdominal surgery) and anaesthesia (general and spinal). Postoperative pulmonary complications occurred in 47·7% of patients who had no respiratory treatment and in 21–22% of those who had different types of respiratory treatment (10). In that study it was found that FEV_1 and FVC were not important factors in the genesis of POPC. When compared to our study, site of operation, presence of respiratory treatment, type of anaesthesia and definition of POPC (new occurrence of three or more respiratory symptoms and signs) are different; smoking prevalence (5%) and percent of patients who had FEV_1 values less than 70% of FVC (17%) were lower; preoperative mean FEV_1 (90% ± 20% of predicted) was higher. Two other frequently quoted studies conducted by Sugimachi *et al.* and Fan *et al.* were different from our study with respect to methodology and site of operation applied (11,12). These studies were retrospective in nature and many patients studied had thoracotomies for oesophageal carcinoma.

It is thought that spirometry could detect clinically occult pulmonary diseases, and therefore could make a major contribution to the risk assessment of POPC in patients missed on clinical examination (22). This study found that POPC developed in three (17·6%) of 17 patients with abnormal preoperative spirometry but no preoperative respiratory symptoms(s) and physical findings. This figure was not higher than overall incidence of POPC (35%) observed in all

patients. This may indicate that spirometry could not detect clinically occult patients in whom POPC risk was high, or that occult lung diseases detected by spirometry were not surgically important. It is well known that spirometric tests reflecting minimal lung pathology show great variability in healthy people (19). Due to relatively large interindividual variability of these tests, considerable overlap between normal and abnormal populations occur (23). Therefore, measures of maximum expiratory flow at medium to low lung volumes are not good predictors of early lung disease (6). In this study, patients with complications had lower mean FEF 25–75% values than those of patients without complications, but incidence of respiratory symptoms and abnormal findings of physical examination did not differ between patients with and without abnormal spirometry. However, there were no differences between patients with and without abnormal spirometry regarding age, gender, smoking and weight which could affect the results of clinical examination.

Spirometry, which has been clinically available since the mid-1950s, has been believed to satisfy the criteria of an ideal screening test: it is inexpensive, readily available, easy to apply, applicable to a larger number of patients, reproducible and has acceptable normal values (24). However, it has not been clearly shown that spirometry has an advantage over less expensive clinical assessment or that improvement in patient outcome is clearly due to spirometry. In this study, POPC developed more frequently in patients with abnormal preoperative findings of physical examination (66·7%) than in patients with normal physical findings (13·9%) (P<0·001). Sensitivity and specificity of abnormal preoperative spirometry to predict POPC were lower than those of abnormal findings of physical examination (Table 7). These findings indicate that spirometry may not be an ideal screening test to predict POPC. In support of this conclusion, there were no differences between patients with and without abnormal spirometry regarding duration of operation, duration of hospital stay after operation, ASA class and prevalence of pneumonia developed (a serious pulmonary complication). However, POPC incidence was found to be higher in patients with lower preoperative FEV_1 (less than 1·25 l or less than 50% of predicted). It seems that preoperative spirometry may be beneficial to predict POPC among a specific subset of patients with severe pulmonary disease.

Many studies suggest that there are multiple risk factors responsible for the development of POPC (advanced age, obesity, smoking, longer operation time, proximity of incision to diaphragm and

Table 7 The value of some preoperative assessments to predict postoperative pulmonary complications

	Preoperative abnormal blood gases	Preoperative abnormal spirometry	Preoperative symptoms related to respiratory system	Preoperative abnormal findings from physical examination
Sensitivity	0·24	0·67	0·29	0·76
Specificity	0·82	0·56	0·82	0·79
Rate of false negative	0·76	0·33	0·71	0·23
Rate of false positive	0·18	0·44	0·18	0·20
Accuracy of positive prediction	0·57	1·48	0·62	1·14

presence of lung pathology), so it is difficult to decide the operation based on spirometry alone (15). Results from this study agree with this thought. Findings from this study show that presence of abnormal preoperative spirometry, abnormal findings of physical examination, advanced age, smoking, higher ASA class and longer operation time are risk factors for pulmonary complications. We suggest that it would be useful to devise a new multifactorial risk index to detect patients at high risk of POPC.

The studies aimed to investigate the role of spirometry as a screening test have provided conflicting results. As most of these studies were conducted many years ago and may not meet the exacting scientific and statistical standards demanded today, a definitive conclusion of the role of preoperative spirometry to predict postoperative pulmonary complications is not available today (4,13,14). Minimum criterium recommended for the studies in this field were followed in this study: we identified the complications prospectively; study population was well defined; it was clear whether or not patients were excluded for surgery; pulmonary complications were clearly defined and described; and the value of preoperative spirometry was characterized in terms of sensitivity and specifity (6,25). However, the complications could not be classified in terms of their clinical severity, and the effect of spirometry on patient's outcome and the cost-effectiveness of spirometry could not be determined. We need studies without these shortcomings to clarify the role of spirometry in predicting the patients at high risk. It is the authors' opinion that the most important deficiency regarding comparisons between results in this field is the lack of a common definition and determination of POPC and their severity.

We conclude that POPC after elective upper abdominal surgery is still common (35%) and it is an important cause of postoperative morbidity.

Multiple factors, which include abnormal preoperative spirometry, are responsible for the genesis of POPC. However, spirometry used alone has a limited benefit to predict POPC after upper abdominal surgery.

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