Pulmonary function after extracorporeal shock wave lithotripsy - a comparison of general and regional anaesthesia

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The effect of general anaesthesia on postoperative pulmonary mechanics was studied by comparing pre- and postoperative spirometry in 30 patients undergoing extracorporeal shock wave lithotripsy, 15 of whom received a unilateral intercostal nerve block, the remainder a general anaesthetic. Both groups of patients had significant postoperative changes in peak expiratory flow rate, expiratory reserve volume and vital capacity; forced expiratory volume at one second was not significantly changed in either group. There were no significant differences in the pre- or postoperative mechanics between the two groups. We conclude that general anaesthetics do not play a significant role in the generation of abnormalities in postoperative spirometry.

Anaesthesia and surgery combine to create significant pulmonary dysfunction in both the intraoperative and postoperative periods.¹⁻¹⁴ Previous reports have chronicled these changes without defining their aetiology.²⁻⁵

We have attempted to delineate the specific effects of general anaesthesia on postoperative spirometry by studying two groups of patients undergoing extracorporeal shock wave lithotripsy (ESWL). We compared the changes in spirometry in patients receiving general anaesthesia with a control group of patients who received a regional anaesthetic (unilateral four-level intercostal nerve block with local infiltration) for their ESWL procedure.

Key words

COMPLICATIONS: anaesthesia, respiratory; LUNG: function, postoperative; MEASUREMENT TECHNIQUES: spirometry.

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Methods

Thirty patients were included in the protocol which was approved by the human research committee; half received regional anaesthesia while the remainder received general anaesthesia. Twenty of the patients were male. Patient age ranged from 24-69 years. The patient demographics are listed in Table 1. A careful history and physical examination were obtained the evening before surgery and all patients with cardiopulmonary disease, significant smoking history (greater than five pack years), or abnormal chest radiograph were eliminated from the study. Those patients included in the study were then assigned on an alternating basis to either regional or general anaesthetic groups.

Preoperative pulmonary function testing was done in the ESWL suite approximately one hour before induction of the anaesthetic. Pulmonary function testing was performed with the patient seated in a chair using standard technique.¹⁵ Spirometry was performed with S&M Instrument Company's Pulmo-Screen II system using the S&M Screen-Mate pneumotachograph volume-flow output spirometer. The spirometer was calibrated daily with a three litre syringe and standard tables were used to obtain predicted values.¹⁵ The flow-volume loop was performed a minimum of three times to ensure reproducibility. The slow vital capacity manoeuvre was performed at least twice with reproducible results.

At the conclusion of the preoperative testing, the anaesthetic began. All patients received intravenous premedication consisting of 50 µg of fentanyl and 5-10 mg of diazepam. General anaesthesia was induced with 3-4 mg·kg⁻¹ of thiopentone and succinylcholine (1 mg·kg⁻¹) was used to facilitate tracheal intubation. Anaesthesia was maintained with isoflurane (0.5-2.0 per cent inspired) and 50 per cent nitrous oxide in oxygen. Mechanical ventilation was instituted with minute ventilation set at 90 ml·kg⁻¹ and at a rate of 10 breaths·min⁻¹. At the conclusion of the operative procedure, the patients

were allowed to resume spontaneous ventilation and were extubated. All patients received oxygen by facemask at $6 \text{ L} \cdot \text{min}^{-1}$ flow of oxygen in the recovery room for approximately 30 minutes.

Those patients receiving regional anaesthesia were placed in the prone position and, using aseptic technique, unilateral T9–12 intercostal nerve blocks were performed together with local infiltration in the field of the anticipated shock wave as previously described.¹⁶ Lidocaine, one per cent with 1:200,000 epinephrine, was used as the local anaesthetic in a total dose of 40–50 ml. These patients were discharged to their rooms at the completion of the procedure.

Anaesthetic time began when the patients received the intravenous premedicants and concluded when the patient left the ESWL suite. The postoperative studies were performed in the ESWL suite approximately 16–20 hours after the completion of the operative procedure. The patients were asked to quantify any pain that they were having on an analogue pain scale from 0 (no pain) to 10 (severe pain). All patients reported pain scores of less than 2 at the time of the postoperative study. No patient received any narcotic analgesic within four hours of the study.

Statistical analysis of the data was performed using Statworks® software and an Apple® computer. Paired Student's *t* test was done within groups and unpaired *t* tests between groups; a *P* value of <0.05 was considered statistically significant.

Results

The results of pre- and postoperative pulmonary function testing are listed in Table II.

Anaesthesia time ranged between 50 and 90 minutes with no significant difference between the two groups.

Significant depression of the peak expiratory flow rate, expiratory reserve volume and vital capacity was observed in both study groups. There were no significant changes measured in the FVC, FEV₁, or IC. There was no statistical difference between the pre- and postoperative respiratory mechanics of patients who received the ESWL treatment under general anaesthesia when compared with patients who received the regional technique.

Discussion

Although disordered pulmonary function as a sequel to anaesthesia and surgery was first reported by Beecher in 1932,¹ the aetiology of the changes remains obscure. Induction of anaesthesia causes a significant impairment of functional residual capacity resulting in atelectasis, shunting and hypoxaemia.^{6,7,10–12} In the postoperative period, the vital capacity is depressed with a gradual return to normal over the following seven to ten

TABLE I

<i>n</i>	Regional anaesthetic 15	General anaesthetic 15
Age	47 ± 7	45 ± 8
Male/female	11/4	9/6
Weight (kg)	73 ± 5	71 ± 6
Duration of procedure (min)	70 ± 10	74 ± 9

All values are mean ± SEM.

days.^{2,3,13} Paradoxically, the FRC is normal in the immediate postoperative period; marked depression occurs approximately 16 hours later with a slow return to baseline in the following seven to ten days.^{2,3,13} These mechanical changes are most pronounced following thoracic and upper abdominal surgery, but have been documented following lower abdominal and extremity surgery.^{3,4} The multiphasic change in FRC has led investigators to speculate that general anaesthesia may play little role in the postoperative mechanics that are observed.¹³ This speculation has not, to our knowledge, been carefully examined and it is still commonly assumed that a regional or local technique is associated with less postoperative depression of pulmonary function than the administration of a general anaesthetic.¹⁴

The FRC is the test which best measures pulmonary reserve;¹³ however, the more easily obtainable values of VC, FVC and FEV₁ have previously been shown to serve as valuable predictors of postoperative pulmonary morbidity and mortality.^{2–4} Further, because the FRC consists of the ERV and the usually stable residual volume, decreases in the measured ERV likely reflect decreases in the FRC. For these reasons, we elected to study pre- and postoperative spirometric changes. The effort dependence of spirometry can make data so obtained difficult to interpret. However, there was little significant variation between patient trials, which gave us confidence in our data.

Pain must always be considered when analyzing postoperative spirometry. Previous investigators have shown that treatment of postoperative pain with epidural anaesthetics and analgesics results in improvement but not restoration of lung capacities.^{17–19} Fortunately, the noninvasive nature of the ESWL procedure generates little postoperative discomfort. None of our patients complained of significant postoperative discomfort or had significant analgesic requirements. We felt that this was important because postoperative pain could prevent full cooperation with the spirometric examination and thereby bias the data.

The lack of significant demographic differences allowed the formation of two study groups where the only

TABLE II

<i>Patients</i>	<i>n</i>	<i>Expiratory reserve volume (Litres)</i>		
		<i>pre</i>	<i>post</i>	<i>p</i>
Regional	15	2.09 ± 0.65	1.73 ± 0.51	0.005
General	15	1.74 ± 0.63	1.49 ± 0.45	0.01
		<i>Peak expiratory flow rate (L·sec⁻¹)</i>		
		<i>pre</i>	<i>post</i>	<i>p</i>
Regional	15	9.76 ± 3.45	8.47 ± 2.74	0.004
General	15	8.69 ± 3.54	8.05 ± 3.04	0.02
		<i>Slow vital capacity (Litres)</i>		
		<i>pre</i>	<i>post</i>	<i>p</i>
Regional	15	4.64 ± 1.07	4.43 ± 1.01	0.01
General	15	4.48 ± 1.10	4.26 ± 0.82	0.01
		<i>Forced vital capacity (L/M)</i>		
		<i>pre</i>	<i>post</i>	<i>p</i>
Regional	15	3.93 ± 1.09	3.84 ± 1.07	NS
General	15	3.77 ± 0.69	3.38 ± 0.68	NS
		<i>Forced expiratory volume 1 sec (L/M)</i>		
		<i>pre</i>	<i>post</i>	<i>p</i>
Regional	15	3.41 ± 0.85	3.32 ± 0.88	NS
General	15	3.40 ± 0.71	3.31 ± 0.67	NS
		<i>Inspiratory capacity (Litres)</i>		
		<i>pre</i>	<i>post</i>	<i>p</i>
Regional	15	2.56 ± 0.55	2.69 ± 0.73	NS
General	15	2.74 ± 0.79	2.80 ± 0.72	NS

All values are mean ± SEM.

variable was anaesthetic technique. Review of the data revealed no measurable differences in respiratory mechanics of the group receiving general anaesthesia compared with the group receiving regional anaesthesia. Paradoxically, both groups showed a significant decrease in PEFR without significant changes in FEV₁; these tests both measure large airway function and one would anticipate parallel changes in the two tests. The PEFR is defined as the highest expiratory flow rate sustained for at least 10 msec.²⁰ However, the PEFR cannot be measured with precision because the flow rate at any given lung volume is determined by a tangent to its point on the timed spirogram. It likely is this inaccuracy in the measurement

of PEFR that created the discrepancy. One would speculate that the FEF 200-1200, a better measure of expiratory flow, would be consistent with the FEV₁. Unfortunately, our computer did not generate this data.

Each group showed comparable significant decreases in the ERV and slow vital capacity. This is consistent with previous publications and the aetiology of these changes has been the source of much speculation. Most recent work has focused on the reduced activity of lower intercostal and abdominal musculature after anaesthesia and surgery as a mechanism for postoperative pulmonary dysfunction.²¹ The aetiology of these changes remains unclear, and our study did not attempt to elucidate it.

Rather, because we could detect no effect of general anaesthesia in routine postoperative pulmonary spirometry it appears that the mechanism of pulmonary dysfunction seen during general anaesthesia is different from that causing postoperative pulmonary abnormalities. We conclude from our data that general anaesthetics do not play a significant role in the generation of abnormal spirometry in the postoperative period.

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Résumé

Nous avons évalué l'impact de l'anesthésie générale sur la mécanique pulmonaire post-opératoire en faisant des mesures spirométriques avant et après 30 séances de lithotritie extracorporelle par ondes de choc. Chez 15 patients, l'anesthésie consistait en un bloc intercostal, tandis que les 15 autres recevaient une générale. Après l'intervention, le débit expiratoire de pointe, le volume de réserve expiratoire et la capacité vitale étaient modifiés chez les deux groupes alors que le volume expiratoire maximum seconde demeurait inchangé. De fait, les mécaniques pulmonaires pré- et postopératoires étaient comparables d'un groupe à l'autre. Ainsi, l'anesthésie générale en tant que telle n'est pas responsable des anomalies décelées par la spirométrie en post-opératoire.