Prognostic value of perioperative lung ultrasound for postoperative pulmonary complications following major upper abdominal interventions

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Background & Goal

The major upper abdominal interventions are associated with a high risk and incidence of postoperative pulmonary complications (PPC) that can be effectively recognized and monitored with lung ultrasound (LUS).^{1,2}

The goal of this study was to assess the predictive value of perioperative LUS for PPC including transient arterial hypoxaemia and atelectases after major open elective pancreatoduodenal surgery.

Methods

Thirty-three adult patients scheduled for elective pancreatoduodenal interventions were enrolled into a single-center ongoing pilot prospective study. All patients were ventilated with protective parameters: tidal volume (V_T) 6 ml/kg predicted body weight and positive end-expiratory pressure (PEEP) 5 cm H₂O.

The LUS studies were conducted before and 24 hrs after the intervention with a summarized assessment of consolidations, pulmonary oedema, and pleuritis in three standard points on both sides of the chest. After summation of points the average value of LUS score was calculated. Plain chest radiogram was performed at 24 hrs postoperatively.

Cardiopulmonary and respiratory parameters were registered during surgery and up to 48 hrs of the postoperative period.

The statistical analysis was performed using Mann–Whitney *U*-test, Wilcoxon's test and ROC-analysis. Data are presented as median (25th–75th percentiles). *p* values < 0.05 were regarded as statistically significant.

Results & Discussion

Perioperatively, we observed an increase in the incidence of pulmonary consolidations and number of B-lines referring to pulmonary oedema (Figure 1).

We found strong-to-moderate correlations between the pre- and postoperative LUS scores for both consolidations ($\rho = 0.83$; $p < 0.001$), and the number of B-lines ($\rho = 0.55$; $p = 0.007$).

Table 1. The key study characteristics.

Characteristic	Value
Age, yrs	59 (53–65)
Gender (M / F)	14 / 19
Body mass index (kg/m ²)	25.4 (23.1–30.1)
Smoking, n (%)	15 (45.5)
Duration of intervention, min	205 (173–250)
Summary duration of the perioperative MV, min	510 (316–656)
Duration of the postoperative MV, min	233 (88–405)
Length of the ICU stay, hrs	47 (24–131)
Length of the hospital stay, days	16 (14–26)
The structure of nosology	
• Pancreatic neoplasm.	21 (64 %)
• Adenocarcinoma of the duodenal papilla.	3 (9 %)
• Chronic calculous pancreatitis.	5 (15 %)
• Hepatic neoplasm	4 (12 %)
Postoperative pulmonary complications	
• Hypoxaemia at 48 hrs ($\text{PaO}_2/\text{FiO}_2 \leq 300$ mm Hg).	10 (30 %)
• Interstitial syndrome / pulmonary oedema.*	17 (51 %)
• Hospital-acquired pneumonia.**	2 (6 %)
• Hydrothorax*	5 (15 %)
Mortality at Day 28, n (%)	2 (6)

* — according to postoperative lung ultrasound; ** — according to clinical investigations and chest X-ray. MV — Mechanical Ventilation.

Figure 1. The perioperative change in consolidation and B-lines (pulmonary oedema) LUS-scores.

* — $p < 0.001$ using Wilcoxon test compared with the values on Baseline. US, ultrasound

Figure 2. The correlation between the consolidation LUS-score and $\text{PaO}_2/\text{FiO}_2$ ratio at 48 hrs.

Figure 3. ROC-curve for the value of postoperative pulmonary consolidation (LUS-score) to predict postoperative hypoxaemia ($\text{PaO}_2/\text{FiO}_2 \leq 300$ mm Hg) at 48 hrs.

The total degree of LUS consolidations in the pre- and postoperative periods correlated with $\text{PaO}_2/\text{FiO}_2$ ratio at 48 hours after intervention only ($\rho = -0.37$, $p = 0.04$, and $\rho = -0.46$, $p = 0.008$, respectively; Figure 2).

At 48 hrs after surgery, the transient arterial hypoxaemia ($\text{PaO}_2/\text{FiO}_2 \leq 300$ mm Hg) was registered in 10 patients (30 %). The incidence of postoperative pleuritis was 15% (5 patients) without indications to surgical drainage.

We revealed the nonsensitive predictive role of the preoperative LUS consolidation score for to the hypoxaemic events ($\text{PaO}_2/\text{FiO}_2$ below 300 mm Hg) at 48 hours after intervention (AUC 0.71, specificity 100%, sensitivity 30%).

At 24 hrs, postoperative LUS score have allowed a reliable prognostication for delayed hypoxaemia at 48 hrs with AUC 0.79, specificity 82%, and sensitivity 70% (association criterion > 6 pts. of LUS-score; $\text{CI}_{95\%}$ 0.61–0.91; $p = 0.002$) (Figure 3).

Conclusions

In open elective pancreatoduodenal surgery, the perioperative lung ultrasound is a reliable and specific tool to diagnose PPC including atelectases and to predict delayed postoperative hypoxemia.

Further studies are warranted to assess a clinical rationale to use the postoperative lung ultrasound as one from the “fit for ICU discharge” criteria.

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