assigned to be ventilated with PEEP 5 cmH_2O ($PEEP_5$) or with PEEP 15 cmH_2O ($PEEP_{15}$). After induction of anesthesia (T1), tidal volume was set at between 6 to 8 ml/kg/PBW and each PEEP was applied after lung recruitment maneuvers before the establishment of pneumoperitoneum and the Trendelenburg position (T2). Airway and esophageal pressures were measured and elastances of respiratory system, chest wall, and lung were calculated at T1, T2 and 20 min (T3), 60 min (T4), 120 min (T5) after the patients being placed in the steep Trendelenburg position and at end of surgery (T6). Differences in elastances and fraction of regional ventilation distribution of the dependent part monitored by EIT were compared at each time point. Data was analyzed by one-way ANOVA with repeated measures and Tukey test as post-hoc analysis for the comparison within group. Independent t-tests or Mann-Whitney U tests were used for the comparisons between the groups.
Results and Discussion: Elastances of chest wall and respiratory system increased at T3, T4 and T5 compared to T2 ($p < 0.05$) in both groups, and were significantly higher in $PEEP_5$ compared to $PEEP_{15}$ ($p < 0.05$). The fraction of ventilation distribution of the dependent part at T3, T4 and T5 was significantly lower than at T2 in $PEEP_5$, but not in $PEEP_{15}$. The intergroup comparisons showed significantly higher distribution in $PEEP_{15}$ than in $PEEP_5$ at T3, T4 and T5. P/F ratio was higher in $PEEP_{15}$ between T2 to T6, especially there was significant difference at T3 and T6. However, the lung elastane revealed no statistical differences between the two groups at any time point.
Conclusion: Elastance of chest wall increased during pneumoperitoneum and Trendelenburg position, leading to the impairment of the ventilation distribution at dependent part of the lungs. Higher PEEP could prevent lung collapse and keep the better ventilation distribution, which leads to maintenance of oxygenation.

11AP05-3
Does pressure-controlled ventilation–volume guaranteed differ from volume-controlled ventilation in anesthetized patients under deep neuromuscular block undergoing robotic surgery

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Background and Goal of Study: The purpose of this study was to investigate the changes in airway pressure and arterial oxygenation between pressure-controlled–volume guaranteed (PC-VG) and volume-controlled ventilation (VC) in anesthetized patients under deep neuromuscular block (DNB) undergoing robotic surgery.
Materials and Methods: After approval by the local ethics committee and after obtaining informed written consent, a total of 30 patients scheduled for robotic surgery under general anesthesia were included. After pneumoperitoneum (12 mmHg) and Trendelenburg (25º), mechanical ventilation was started with VC for 60 min, then PC-VG was applied to all patients with the same parameters, targeting the obtained tidal volume (Vt). All patients were ventilated with a Genesis Anesthesia Workstation (Hersill, Spain). DNB (PTC 1-3) was maintained using continuous infusion of rocuronium. I:E ratio 1:2, PEEP of 5 cmH_2O and FiO_2 of 60% was applied to all patients.
Arterial blood pressures, heart rate, $ETCO_2$, SpO_2, pH, $PaCO_2$, and PaO_2 were measured after 30 and 60 min. of VC and after 30 and 60 min. of initiation of PC-VG. Tidal volume, mean airway pressure (MAP), and peak airway pressure (PAP) were also recorded. PAFi (PaO_2/FiO_2) and Oxygenation index (OI) [$PaO_2/(FiO_2 \times Pmean)$] calculation was performed at the preset times. The pressure sensors in the ventilator measured the patient airway pressures. Continuous variables are expressed as mean +/- SD. Data were compared using ANOVA. P-value of 0.05 or less was considered statistically significant.
Results and Discussion:

	VC 30 min.	VC 60 min.	PC-VG 30 min.	PC-VG 60 min.	P-value
PAP	29.06+/-5.42	28.78+/-5.06	26.66+/-5.09	26.04+/-5.14	p≤0.05
cmH_2O MAP	10.95+/-1.91	10.90+/-1.94	11.46+/-2.12	11.73+/-2.12	p≤0.05
cmH_2O OI	281.05+/-53.8	274.61+/-68.96	281.00+/-86.86	271.83+/-65.94	p≥0.05
(cmH_2O/mmHg) PAFI	4.06+/-1.14	4.33+/-1.77	4.54+/-1.94	4.64+/-1.93	p≥0.05
mmHg					

Conclusion: While maintaining constant Vt and I/E ratio and under DNB there are significant differences in airway pressures. PAFI and OI were comparable between both VC and PC-VG modes of ventilation.

11AP05-4
Diaphragm ultrasound as a method to predict ventilation outcome in children: the prospective observational cohort study

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Background and Goal of Study: Diaphragm dysfunction worsens outcomes in mechanically ventilated patients. However, the clinical impact of changes in diaphragm structure and function due to mechanical ventilation (MV) is unknown. The hypothesis was that in children the duration of MV and the duration of stay in the intensive care unit, the frequency of complications depend on the degree of diaphragm atrophy. The aim of the study was to determine whether diaphragm atrophy developing during MV leads to prolonged ventilation.
Materials and Methods: We investigated data of 54 patients at the age 1 month-1 year admitted in Lviv Regional Children Clinical Hospital “OCHMATDYT”, who needed invasive MV and were eligible for measurement of diaphragm function. 4 patients were excluded due to the neuromuscular disease and bronchopulmonary dysplasia, in the 2 patients ultrasound investigation was impossible. 48 patients were included in the study results analysis and all of them had two or more diaphragm thickness measurements. Diaphragm thickness (Tdi) at end of inspiration and diaphragmatic excursion were measured daily by ultrasound in children requiring invasive MV, evaluating an inspiratory effort was assessed by thickening fraction. The primary outcome was time to liberation from ventilation. The secondary outcomes included complications (reintubation, tracheostomy, prolonged ventilation, or death). We use Statistical Package for the Social Sciences and results were presented using adjusted hazard ratio (HR), duration ratio, and odds ratio (OR).
Results and Discussion: Thickness decreased to more than 10% in 30 patients (63%) by median day 6 (IQR 5-7). Development of decreased thickness was associated with a lower daily probability of liberation from ventilation (adjusted HR 0.47, 95%CI 0.38-0.62, per 10% decrease), prolonged ICU admission (duration ratio 1.63, 95%CI 1.25-2.44), and a higher risk of complications (OR 2.14, 95%CI 1.21-4.72). Development of increased thickness (n=8, 17%) also predicted prolonged ventilation (duration ratio 1.38, 95%CI 1.00-1.90). Decreasing thickness was related to abnormally low inspiratory effort; increasing thickness was related to excessive effort. Patients with thickening fraction between 15-30% during the first 4 days had the shortest duration of ventilation.
Conclusion: Diaphragm atrophy developing during MV strongly impacts clinical outcomes.

11AP05-5
Automated control of mechanical ventilation during general anaesthesia –preliminary results of a bicentric observational study

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Background and Goal of Study: Several systems for automated control of mechanical ventilation exist on intensive care ventilators that were successfully applied in clinical studies (1-2). The goal of this study is to examine the safety and efficacy of a novel system for automated control of ventilator settings on an anaesthesia machine.
Materials and Methods: The novel system called Smart Ventilation Control (SVC) controls automatically the mechanical breathing frequency, inspiratory pressure, pressure support, inspiratory time and trigger sensitivity with the aim to keep the patient stable in user-adoptable target zones. Patients are eligible for study inclusion when all of the following criteria are met: American Society of Anaesthesiologists (ASA) physical status I, II or III, elective surgery of the upper or lower limb or for peripheral vascular surgery in general anaesthesia, written consent for study participation. Primary endpoint of the study is the frequency of the following adverse events: Severe hypopnea defined as minute ventilation lower than 40 ml/kg predicted body weight for longer than 5 minutes, apnea for longer than 90 seconds, hyperventilation defined as end-tidal partial pressure of CO2 (PetCO2) lower than 5 mm Hg of the lower target setting for SVC for longer than 5 minutes, hypoventilation defined as PetCO2 higher than 5 mm Hg of the upper target setting for the SVC for longer than 5 minutes, respiratory rate ≥ 35 breaths/minute for longer than 5 minutes, any override or stop of the automated controlled ventilation settings by the anaesthesiologist in charge if the settings are clinically not acceptable.
Results and Discussion: The analysis of the first 14 included patients with a mean age ±standard deviation of 52±17 years and a mean height of 172±8 cm revealed that SVC performed well and no interruption of the study protocol occurred. Regarding the primary endpoint, no adverse event was noted. We plan to recruit a total of 100 patients.
Conclusions: This is the first clinical study of a system that automatically controls most of the ventilator settings on an anaesthesia machine. Our preliminary results suggest that this novel system is safe.
References:
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11AP05-6
Sudden ventilation failure during left one lung ventilation for robot-assisted right upper lobectomy in a patient after left upper division segmentectomy

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Background: In patients after left upper lobectomy (LUL), U- or V-shaped angulation of the left main bronchus (LMB) develops with expansion of the left lower lobe. We reported that a standard left-sided double-lumen tube (LDLT) cannot be used to achieve successful one-lung ventilation (OLV) for right lung surgery in post-LUL patients with remarkable LMB angulation, characterized by a combination of a wide angle (> 140°) between the trachea and LMB and a narrow angle (< 100°) between the LMB and left lower bronchus, whereas it can be used safely in patients with unremarkable angulation (J Cardiothorac Vasc Anesth. 2016;30:961-6). Herein, we present a female after left upper division segmentectomy (LUDS) with unremarkable LMB angulation scheduled for robot-assisted thoracic surgery (RATS), in whom ventilation failure occurred with a standard LDLT immediately after she was placed in a lateral jack-knife position required for RATS.
Case Report: A 73-year-old female was scheduled to undergo RATS for right lung cancer. She had undergone LUDS for adenocarcinoma 5 years before. A chest X-ray revealed that she had LMB angulation, albeit unremarkable. After induction of general anesthesia, a standard LDLT (35Fr Portex blue line®) was placed correctly with video laryngoscopy and bronchoscopy. Pressure-controlled ventilation was used for OLV. Adequate OLV could be achieved during test OLV while she was placed in the supine position, and also in the left lateral position. However, ventilation failure occurred as soon as she was placed in the lateral jack-knife position with the waist raised. Fiberoptic examinations revealed that the tip of the bronchial lumen was completely obstructed by the LMB wall despite correct LDLT placement. The LDLT was exchanged to another type of LDLT with a soft, flexible, wire-reinforced tip (Silbroncho®, 37Fr) using a tube exchanger and video laryngoscopy while she remained in the lateral position. Thereafter, adequate OLV could be achieved even after she was replaced in the lateral jack-knife position. The scheduled RATS could be completed uneventfully.
Discussion and Learning points: Our experience suggests that ventilation failure with a standard LDLT can occur more easily when a patient with LMB angulation is placed in a lateral jack-knife position than simple lateral position probably due to more significant posture-induced exacerbation of bronchial angulation, and that Silbroncho® tube is useful to overcome this problem.

11AP05-7
Evaluation of a non-invasive respiratory volume monitor without patient-specific calibration

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Background: Continuous monitoring of respiratory status is important for identifying potentially life-threatening respiratory compromise, performing clinically appropriate interventions, and monitoring patient recovery. A recently developed non-invasive Respiratory Volume Monitor (RVM) has been shown to have better than 10% accuracy for minute ventilation (MV), tidal volume (TV), and respiratory (RR) in both non-intubated and intubated patients. The current RVM requires a patient-specific calibration with a spirometer. To facilitate broader use, the RVM has been updated to measure MV and TV without the need for a patient-specific calibration. Here, we evaluated the accuracy of the RVM without patient-specific calibration compared to three FDA-cleared devices.
Methods: 20 subjects from a broad ambulatory population (11 males, BMI=26.8 kg/m2 (18-41), 49.2 yrs (22-80)) had MV, TV, and RR simultaneously recorded by the RVM without a patient-specific calibration and a comparison device: Pneumotachometer (Heated FVL, Morgan Scientific), Wright Respirometer (Mark 14, nSpire Health), and RVM with patient-specific calibration (ExSpiron, Respiratory Motion). Subjects completed 3 trials on Day 1 and repeated them on Day 2, wearing electrode pads continuously for 24 hours. Relative errors in measurements of MV, TV, and RR were calculated. Bias, precision, and accuracy were calculated using Bland-Altman analyses. Paired-difference equivalence tests were performed with equivalence margins of 10% relative error.
Results: The RVM’s mean measurement biases for MV and TV were within 2.2% compared to all three comparison devices and within 0.2% for RR (Table 1). The mean measurement accuracies were better than 11.6% for MV and TV and better than 4.1% for RR (Fig 1A). Equivalence tests showed that MV, TV, and RR were equivalent within ±10%.
Conclusion: We demonstrated that the RVM can deliver accurate MV, TV, and RR measurements without the need for patient-specific calibration. This new capability streamlines the workflow of the RVM and enables healthcare providers to provide continuous and non-invasive respiratory assessments in a broader variety of clinical settings.

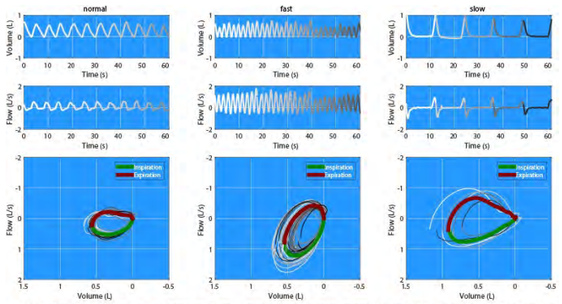

Figure 1. Representative volume (top row), flow (middle row), and flow-volume loops (bottom row) for normal (left column), fast (middle column), and slow (right column) breathing trials. The flow-volume loops display all breaths during the breathing trials as well as the average inspiratory (green) and expiratory (red) curves. Note that both axes are reversed in accordance with common presentation of flow-volume loops.

11AP05-8
Assessing the effects of duration of apnea on adequacy of ventilation across a broad cohort of surgical patients in the post-operative environment

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Background: Maintaining respiratory sufficiency is a vital component of postoperative care, yet clinicians often rely on subjective clinical assessments or secondary indicators of respiratory status. Patients with apneic episodes are often considered to have “respiratory insufficiency” regardless of whether these apneic episodes impact overall respiratory status or are compensated by large recovery breaths. We used a non-invasive respiratory volume monitor (RVM) to quantitate minute ventilation (MV) to assess ventilation in patients experiencing apnea in the PACU and on the general floor.
Methods: We used an RVM (ExSpiron1Xi, Respiratory Motion, Waltham, MA) to continuously monitor MV for 48 hr following elective abdominal surgery. MV was expressed as percent of MV predicted (MVPRED) based on body surface area and sex; Low MV (hypoventilation) was defined in previous work as MV<40% MVPRED. For each apnea, defined as a pause >10 s, we calculated the patient’s MV over 30, 60, 90, and 120 second windows following the start of the apnea.
Results: 216 patients (110 males, BMI: 26.7 (15-41) kg/m2) were monitored for 42.0±0.9 hr. We recorded a total of 49,985 apneas ranging in length from 10-117s (Fig 1A). Apnea >10sec was observed in 99% of patients, suggesting that apnea per se is a poor indicator of respiratory insufficiency. The average MV was 73±2.4% MVPRED, as patients were often sleeping or mildly sedated. We assessed the effects of each apnea on the temporally associated MV (Fig 1B). While apneas lasting 10-18 s decrease instantaneous MV by as much as 30%, their effect over the course of 1 minute is less than 10%. On a 2-minute time scale, even 60 s apneas lead to Low MV just 20% of the time (Fig 1C).
Conclusion: While apneas were ubiquitous, they seldom led to sustained Low MV over clinically relevant time scales. Compensatory breaths following an apnea generally restored MV to near pre-apnea levels. Nonetheless, some apneas can become dangerous when ignored, as when sedation decreases compensatory breath size. RVM data provides a better overall metric of respiratory competence, driving better assessment of patient risk and individualization of care.

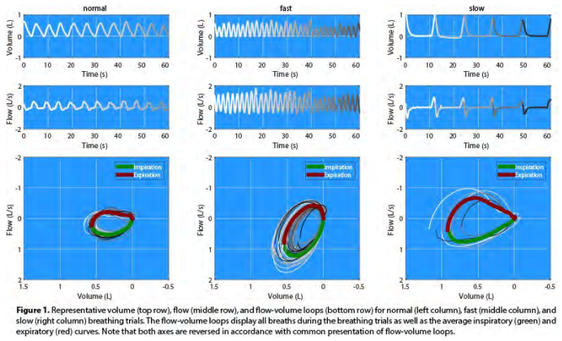

Figure 1. Representative volume (top row), flow (middle row), and flow-volume loops (bottom row) for normal (left column), fast (middle column), and slow (right column) breathing trials. The flow-volume loops display all breaths during the breathing trials as well as the average inspiratory (green) and expiratory (red) curves. Note that both axes are reversed in accordance with common presentation of flow-volume loops.