Carestation Insights Lung Protective Ventilation (LPV) Application Case Study

Leveraging machine data to improve the adoption of lung protective ventilation strategies

Introduction

Mechanical ventilation is an essential supportive therapy during general anaesthesia. However, mechanical ventilation may contribute to impaired oxygenation and gas exchange, primarily due to atelectasis.

THE CHALLENGE

Atelectasis is estimated to occur within minutes of anaesthesia induction and can extend into the postoperative period for up to 90% of patients, making it one of the most common complications in the operating room.[1] **This has been shown to contribute to the development of postoperative pulmonary complications (PPCs),** an increase in mortality rates in some procedures, or higher patient care costs due to the increase of length of stay (LOS).[7] Several studies have clearly demonstrated the negative impact of non-protective ventilation, including the use of high-volume, a very low or zero end-expiratory pressure (ZEEP), and high-plateau pressure.[1,3,8]

These complications may be preventable with small changes to the way a patient is mechanically ventilated during anaesthesia therapy.[1-5] For example, the Intraoperative Protective Ventilation (IMPROVE) trial,[8] a multicenter, double-blind study conducted in 2011 and 2012 by **Professor Futier et al.**, used a Lung Protective Ventilation (LPV) strategy based on three main criteria:

1. Ventilation with a tidal volume of 6 to 8 mL per kilogram of predicted body weight
2. PEEP of 6 to 8 cmH_2O
3. Recruitment maneuvers repeated every 30 minutes after tracheal intubation[8]

THE SOLUTION

The study showed that the use of an LPV strategy in intermediate-risk and high-risk patients undergoing major abdominal surgery was associated with **improved clinical outcomes and reduced healthcare utilization** when compared to the practice of non-protective ventilation.[8]

Based on the evidence from this study, GE Healthcare is developing ways to help clinicians reduce PPCs by providing tools to support the implementation of LPV strategies. Together with GE Healthcare's latest anaesthesia delivery systems, Carestation™ Insights Analytics Application (App) platform creates an intelligent ecosystem that captures and analyzes hundreds of data points with every patient breath. Each Carestation Insights application focuses on helping improve certain clinical, operational, or economic outcomes, transforming the data into useful information designed to be easily accessible on your personal device. For hospitals that seek to implement or maintain an LPV strategy in their operating rooms, there is an App for that.

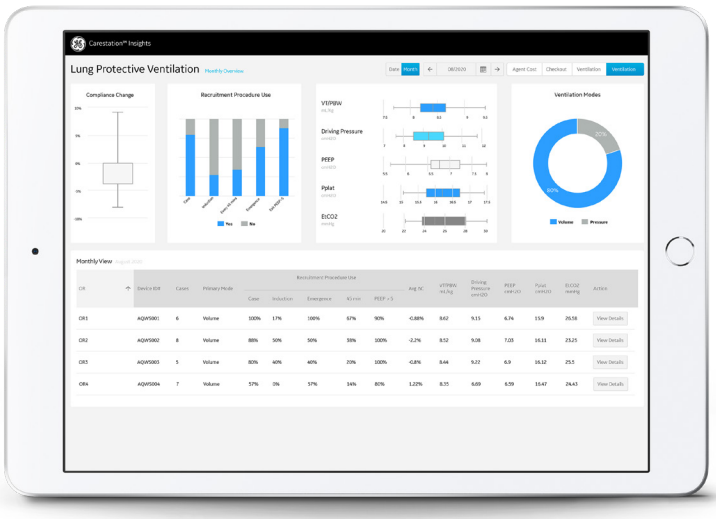


Figure 1: Carestation Insights Lung Protective Ventilation (LPV) Application.

Using advanced algorithms to interpret the ventilation information, the **Carestation Insights Lung Protective Ventilation App** tracks ventilation settings, recruitment procedures, and the resulting intraoperative patient lung responses (Fig. 1) across all connected Aisys™ CS[2] Anaesthesia Delivery Systems (Fig. 2).

THE ADVANTAGE

There is no need for manual data entry or extra resources to analyze the anaesthesia machine data. This LPV application provides the necessary visibility into the operating room to help clinicians make data-driven decisions, drive change, and improve LPV strategy compliance.

LPV Adherence Case Study

To see how the Carestation Insights LPV application works in practice, GE Healthcare partnered with Professor Philippe Cuvillon (head of the Anaesthesia Department), Dr. Christophe Boisson (Anaesthesiologist and specialist in IT solutions), and their team at Nîmes University Hospital in France. Through participation in the IMPROVE multicenter study, the team had become particularly interested in LPV strategies to reduce atelectasis and the risk of pulmonary complications. Although they recognized the value of these strategies, they wanted evidence to guide their efforts, according to Professor Cuvillon. The Carestation Insights LPV App met this need.

The potential of LPV insights

"We were looking for a tool to query the data coming from the ventilators in order to measure how we were following the recommendations. We were very interested by the utilization of a data collection system that starts automatically as soon as a new patient case is opened with no human intervention required. This plus the fact that we could easily get access to Dashboards dedicated to Lung Protective Ventilation providing retrospective visibility into mechanical ventilation settings and recruitment maneuver usage in a safe way. We took this opportunity to launch a quality improvement project on lung protective ventilation strategy."

- Professor Philippe Cuvillon

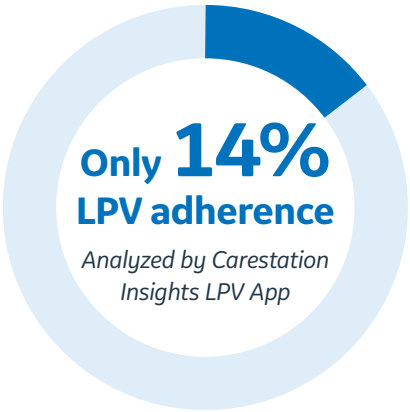
Professor Cuvillon and Dr. Boisson decided to use the application to verify adherence to the LPV strategy that was assumed to be commonly used in their operating rooms, and then seek opportunities to improve the strategy and the adoption rate. The percent of cases using recruitment maneuvers (1 or more) was used as the primary endpoint. They also focused on lung protective parameters such as low Tidal Volumes and adequate pressures (PEEP, Driving Pressure, etc.). This case study was performed in four phases (Table 1) between October 2018 and December 2019. In total, data were available and analyzed for 7,710 cases (patients).

PHASE 1

Baseline - Percent of Cases Using Recruitment Maneuvers

Professor Cuvillon and Dr. Boisson first needed to establish a baseline for their surgical practice to determine if the LPV strategy protocol was being implemented. More than 2,000 cases were captured using the Carestation Insights LPV App over a three-month period, which was defined as Phase 1.

From the beginning, Professor Cuvillon and Dr. Boisson were careful to explain the purpose of this new LPV App to the anaesthesiology teams. They spent time reassuring these teams on the reason they were implementing this solution, and the fact it was not a "big brother" system or confidential monitoring system.



The results of Phase 1 showed only 14% of cases implemented lung recruitment maneuvers (1 or more).

Observations from Phase 1 Baseline

"If we consider the 3 main criteria that define lung protective ventilation, Vt/PBW = 6-8 mL/kg, PEEP = 6-8 cmH_2O and 1 or more recruitment maneuvers per case, overall the results are not bad. We were even good on the main one, Vt/PBW, and not bad on PEEP level. What was disappointing was our ability to generate the recruitment maneuvers, which could be explained by the fact that the users have to do a manual action to initiate the recruitment and (they may) forget to do it most of the time.

Then we immediately saw the opportunity to use the Carestation Insights LPV application as the best way to track our LPV practices, allowing us to evaluate these practices at regular intervals and observe the impact of LPV training solutions put in place to improve our standard of care."

- Professor Cuvillon

PHASE 2

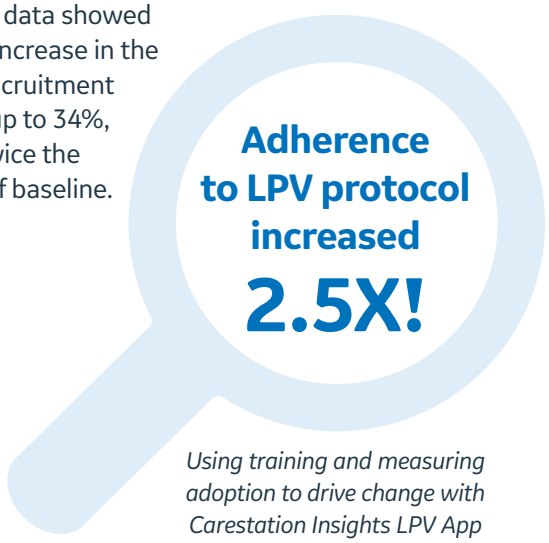
Pursuing LPV Educational Opportunities

Having identified significant room for improvement, the team began an educational campaign of literature reviews, presentations and monthly follow-ups for the anaesthesia department, focusing on LPV strategies and their benefits.

Guidance for anaesthesiologists and nurses to practice a lung protective strategy protocol included:

- **Low tidal volume:** 6-8 mL/kg PBW (Predicted Body Weight)
- **Level of PEEP:** 6-8 cmH_2O
- **Recruitment maneuvers:** implement as early as possible after intubation (over the first 10 min after intubation), each hour, at each de-recruitment, and before extubating

During this educational campaign, the Carestation Insights LPV App continued tracking compliance with this LPV protocol. The data showed a significant increase in the use of lung recruitment maneuvers, up to 34%, more than twice the percentage of baseline.



Using training and measuring adoption to drive change with Carestation Insights LPV App

How the Carestation Insights LPV app supported the LPV strategy

"Improving patient safety during ventilation requires the implementation of recommendations and the analysis of adherence to this practice. To date, ***the analysis of ventilation practices cannot be done in a manual or declarative way. The Carestation Insights solution has demonstrated in our study and in our institution its usefulness to monitor ventilation practices without interfering with daily activities.*** *This tool allows regular audits that will be a valuable aid in the application of LPV recommendations and ultimately to patient safety."*

- Professor Cuvillon

PHASE 3

Post-LPV Training Adherence

Before starting Phase 3, data from Phase 2 were presented to the clinical users. During this 3-month period for Phase 3, training and education was discontinued and the use of recruitment maneuvers decreased slightly, as captured by the LPV App. This emphasized the need for visibility to LPV practices moving forward, so that management could continue to drive desired behavior.

4% drop in LPV adherence post training

As measured by Carestation LPV App

The importance of maintaining LPV practice improvements

"We wanted to observe the impact of stopping any effort to maintain the focus on using protective ventilation over time.

As previously described in all the quality improvement projects, we were able to observe that, without a good LPV practice reminder, users would gradually return to old work habits.

In just a short period of time, we already started seeing a decline in LPV practice – from 34% to 30%. We anticipate that we would have probably seen the decline continue back to the baseline within 1 or 2 years. Therefore, with Dr. Boisson, we were looking for a permanent solution, independent of human factors, and we decided to implement a pop-up message that appears automatically on the screen of the anaesthesia clinical information system just after intubation."

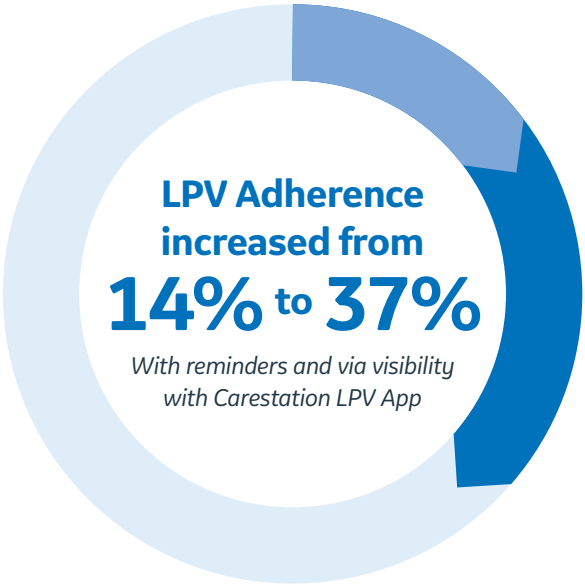
- Professor Cuvillon

PHASE 4

Automated LPV Strategy Reminders

The LPV App provided the necessary insight to take the action of displaying a message on the clinical information system as a reminder for the clinician to perform a lung recruitment maneuver.

After intubation, the anaesthesiologist recorded the intubation in his or her computerized sheet of anaesthesia, and the pop-up message: *"Did you think about lung recruitment?"* appeared automatically on the display. To remove this message, the anaesthesiologist had to click on it.



This addition resulted in an increase in the use of recruitment maneuvers by nearly threefold when compared to the baseline. Through this effort, the study team confirmed that **"not measuring" was the equivalent of "not knowing," and increasing the visibility to the actual ventilation settings and recruitment maneuvers changed behaviors, which led to a significant increase in the rate of LPV protocol adoption.**

Table 1. Case Study Phases – LPV Strategy Adherence*

Phase	Cases	PEEP (cmH_2O) Median (Q1 - Q3)	Vt/PBW (mL/kg) Median (Q1 - Q3)	% of cases using recruitment maneuvers (1 or more)	Driving Pressure (cmH_2O) Median (Q1 - Q3)
1. Baseline LPV protocol	2361	4.5 (3.5 - 5.1)	7.4 (6.8 - 8.0)	14 %	9.9 (8.1 - 12.2)
2. LPV training	2423	4.7 (4.3 - 5.4)	7.5 (7 - 8.2)	34 %	9.6 (8.07 - 11.7)
3. Post-LPV training	1064	5.2 (4.6 - 5.6)	7.4 (6.9 - 7.9)	30 %	9.5 (7.8 - 11.6)
4. LPV protocol reminder	1862	5.4 (4.8 - 5.7)	7.3 (6.9 - 7.8)	37 %	9.3 (7.8 - 11.5)

** The Carestation Insights LPV App was used to measure LPV protocol adherence and provide visibility into LPV practices.*

Conclusion

Even with the best intentions, behavior change can be difficult – evidence-based research may take 17 years to achieve just 50% adoption in clinical practice.[6] A big reason for this is a lack of visibility into the behaviors and the resulting outcomes (operational, clinical and financial).

The Carestation Insights LPV application provided the needed visibility to improve adoption of the lung protection strategy. As an example, a hospital that does an average of 30 surgical cases per day and achieves similar results of improving an LPV adoption from 14% to 34% may see a reduction in over 45 postoperative pulmonary complication cases.[8, 10]

The LPV application is part of GE Healthcare's Carestation Insights suite of analytics applications that can connect behavior and practice with the resulting outcome in a way that encourages clinical, operational, and financial improvements.

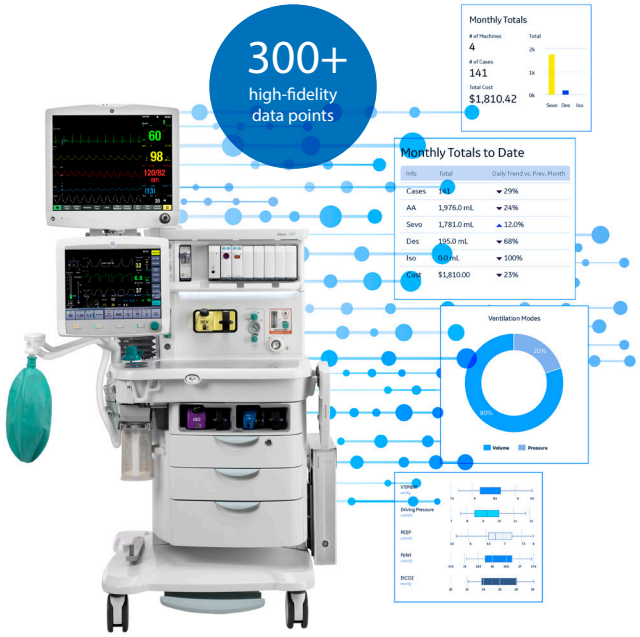


Figure 2: Aisys CS^2 anaesthesia machine data can be analyzed on the Carestation Insights Analytics Apps platform.

Key advantages of the Carestation Insights LPV App

"We could use this application to produce a dashboard of metrics on a large cohort of patients without any human action (no manual data entry) for the purpose of improving adoption of lung protective ventilation and to collect anonymous factual data on LPV protocol adherence (RM: 14% for period 1 to 37% for period 4).

Since the first publications on protective ventilation, several studies have demonstrated the difficulty in recording the adherence of these LPV practices in the operating room as well as analyzing anaesthesia settings used among several ORs.[9] Similarly, the analysis of a new ventilation strategy is difficult over a short time due to the complexity of manual record keeping of anaesthesia machine settings used. Manual recording is time consuming and can cause missing or error-prone data. This study demonstrated that the Carestation Insights LPV software application is able to automatically capture settings from the anaesthesia machine to create a report dashboard in a short period of time, making it easy to use (no human action) for this quality improvement project."

- Professor Cuvillon

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