



GE HealthCare

How Carestation Insights can help

Improve Adequacy of Anesthesia and reduce Major Postoperative Complications

Postoperative complications continue to affect **10–20% of surgical patients**, particularly frail individuals and those undergoing intermediate- to high-risk procedures. These complications are linked to higher mortality, longer hospital stays, reduced quality of life, lower patient satisfaction, and increased healthcare costs.^{1,2,3,4,5}

Research has shown that the combination of **low blood pressure (MAP <60 mmHg for >5 minutes)** and **deep anaesthesia (Entropy™/BIS values <40)** is associated with a higher risk of adverse postoperative outcomes.^{6,7} To address this, a prospective **Adequacy of Anesthesia (AoA)** quality-improvement study involving **1,025 patients** evaluated the impact of monitoring and managing these parameters using **Carestation Insights AoA application**.

The AoA application automatically captures AoA data and combines actual values with the hospital defined targets and unwanted events.

Our study demonstrated that improved adherence to AoA targets was independently associated with⁸:

- Reduced **Intraoperative Hypotension (IOH)**
- Lower incidence of **Acute Kidney Injury (AKI)**
- Fewer postoperative pulmonary complications

Key takeaway: Increased adherence to AoA principles was independently associated with reduced hypotension, kidney injury, and pulmonary complications, demonstrating the potential of automated analytics and monitoring to improve perioperative outcomes.

CHALLENGE



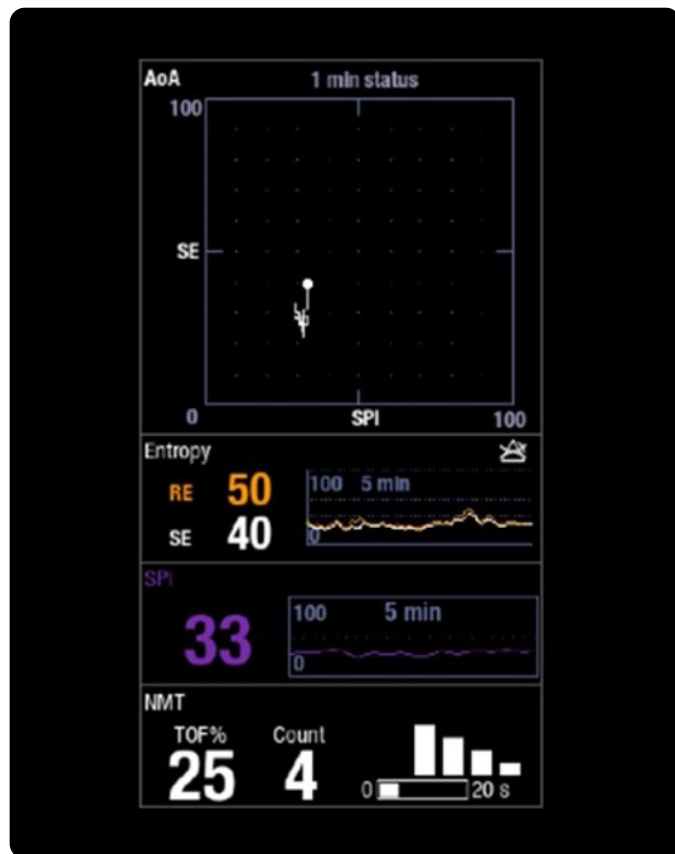
Although depth of anaesthesia and nociception monitoring is available their clinical impact has remained limited in daily practice.^{9,10}

- This may partly be due to lack of clear recommendations or reflects the lack of structured training and implementation strategies in routine anaesthetic care.
- As most anaesthesiologists do not see their patients after being discharged from the operating room, they also miss the long-term effect of anaesthesia which might include cognitive dysfunction or cardiac ischemia 3-5 days post-surgery.
- In addition, we have not been able to monitor the actual use of Adequacy of Anesthesia (AoA) in our hospital.

What is Adequacy of Anesthesia Monitoring

GE HealthCare's Adequacy of Anesthesia (AoA) solution consists of powerful parameters -State Entropy (SE) and Response Entropy (RE), Surgical Pleth Index (SPI), Neuromuscular Transmission Monitoring (NMT)-, consumables and a digital analytics application that may help you in your goals to improve outcomes, save costs and improve workflow efficiency.

Entropy monitoring



GE HealthCare Monitor's BalanceView Feature

Entropy measures the activity of the brain and has been shown to reflect the different phases of anaesthesia. The use of Entropy in adults has been found to optimise the use of certain hypnotic drugs, therefore, helping anaesthesiologists to tailor anaesthetics to each patient, helping avoid unnecessarily deep states of hypnosis, including burst suppression that has been associated with increased risk of delirium, or inappropriately light levels of anaesthesia that may lead to intraoperative awareness.

The recommended range¹¹ during general anaesthesia for both RE and SE is from 40-60, therefore, a decrease of SE below 40 may indicate an unnecessarily deep anaesthesia while an increase above 60 may indicate the need for adjusted titration for deeper hypnosis.

Surgical Pleth Index (SPI) monitoring

SPI is GE HealthCare's proprietary parameter that reacts to haemodynamic responses caused by surgical stimuli and analgesic medications.⁹ Our algorithm uses two components of the photoplethysmographic signal when measured on GE HealthCare's TruSignal™ SpO₂ finger sensors only. Clinical evidence suggests an SPI target range of 20 to 50.^{12, 13}

BalanceView provides clear visualisation of the patient's response to changes in anaesthesia conditions, which may help the anaesthesiologist to adjust the analgesic levels and optimise patient consciousness.

Neuromuscular Transmission (NMT) monitoring

NMT is the transfer of an impulse between a nerve and a muscle in the neuromuscular junction. NMT can be blocked by neuromuscular blocking agents—drugs which cause transient muscle relaxation and prevent the patient from moving and breathing spontaneously.

Postoperative residual curarization (PORC) incidence in post-anaesthesia care units is estimated to be approximately 40%¹⁴. Such residual effects, even at levels of recovery as high as a Train-of-Four (TOF) ratio of 0.7-0.8, have clinical consequences and complications that can prolong hospitalization. Current recommendations advocate the use of short- or intermediate-acting NMBAs, routine reversal of neuromuscular block, and quantitative monitoring of the neuromuscular function whenever relaxants are used, especially before and after reversal.

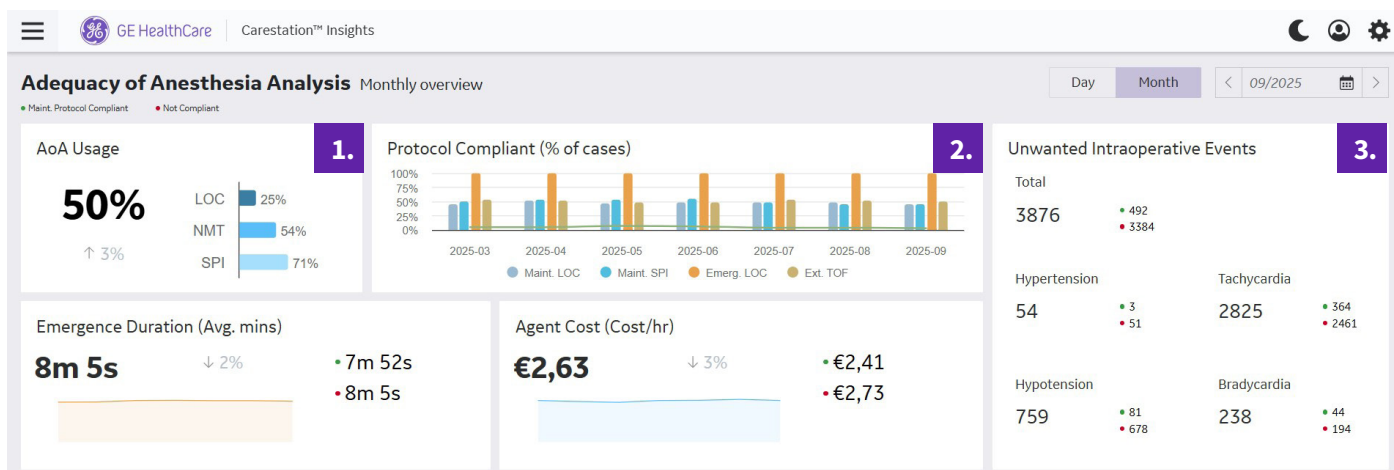
Studies have shown that the implementation of quantitative Electromyography (EMG) monitoring resulted in a significant reduction in the incidence of incompletely reversed patients in the Post-anaesthesia Care Unit (PACU).¹⁵ Adequate recovery from neuromuscular block, indicated by TOF ratio >0.9, can be reliably determined only with a quantitative measurement.

SOLUTION



Carestation™ Insights Adequacy of Anesthesia (AoA) application

Now there's a simple, powerful way to measure and track adherence of your Adequacy of Anesthesia (AoA) protocols, during and after anaesthesia delivery. Carestation Insights AoA application is a mobile digital application that aggregates full fidelity data from GE HealthCare compatible patient monitors and anaesthesia machines. The application presents data and insights in intuitive ways without the need for additional manual data input.



1. AoA Usage (Daily or Monthly)

This pane displays the percent of cases for that AoA parameters are used, in addition to a breakdown of which parameters are used. A trend value is displayed to represent the change when compared to the previous month (Monthly view) or previous day (Daily view).

2. Protocol Compliance (% of cases)

This pane displays the percent of cases that adhere to the set protocols where AoA is used, including Level of Consciousness

values during Maintenance (Maint LOC), Surgical Plethymographic Index values during Maintenance (Maint. SPI), Level of Consciousness values during Emergence (Emerg. LOC), and Train of Four values at Extubation (Ext TOF). Level of Consciousness values include either Entropy or BIS. Protocol information is set in the facility configurations. The previous 6 days are displayed when in Daily view, and the previous 6 months are displayed when in Monthly view. The current day and current month, if displayed, use data from completed cases for that day/month up to the current time.

3. Unwanted Intraoperative Events

This pane displays Unwanted Intraoperative Events based on the criteria set in the facility configurations. This includes Hypertension, Hypotension, Tachycardia, and Bradycardia events. The total number of events is displayed, as well as events that occurred in cases that adhered to the set AoA maintenance protocols (green dot) compared to the cases that did not adhere to the set AoA maintenance protocols (red dot). The hospital specific settings for the unwanted events criteria are described below.

AoA Protocol Target setting

In the AoA Config tab in the AoA application, the hospital admin user can define Protocol Compliance and Unwanted Events Criteria.

Administrator

Overview Agent cost config OR analysis config **AoA config**

Protocol Compliance

*LOC: Level of Consciousness, SE: State Entropy, BIS: Bispectral Index, TOF: Train of Four, SPI: Surgical Pleth Index

1. Maintenance LOC SE or BIS Low 40 High 80 In range target as % of total maint. time 80% ☒ Parameter use required for compliance

Emergence LOC SE or BIS Low 60

2. Extubation TOF% Low 90

3. Maintenance SPI Low 35 High 60 In range target as % of total maint. time 90%

4. Unwanted Events

*MAP: Mean arterial blood pressure, ECG: Electrocardiogram

Blood Pressure(MAP) mmHg Low 60 High 90 Duration 5 min Duration only applies to low BP

Heart Rate(ECG) /min Low 40 High 165

Reset Save Changes

1. Maintenance LOC SE or BIS

Set the desired protocol range for the State Entropy (SE) or Bispectral Index (BIS) measurement for during the Maintenance phase of anaesthesia. Additionally, set the percentage of time for that this range needs to be maintained to count as a case that adhered to the protocol. If the measurement remains within this range for at least the % of total Maintenance time chosen, the case is considered to be in protocol.

2. Extubation TOF%

Set the desired Low limit for the Train of Four ratio % value for extubation. If the measurement remains above the set low limit at extubation, the case is considered to be in protocol.

3. Maintenance SPI

Set the desired protocol range for the Surgical Pleth Index (SPI) measurement for during the Maintenance phase of anaesthesia. Additionally, set the percentage of time for that this range needs to be maintained to count as a case that

adhered to the protocol. If the measurement remains within this range for at least the % of total Maintenance time chosen, the case is considered to be in protocol.

4. Unwanted Events

This pane allows admin user to update the following parameters.

- **Blood Pressure (MAP) mmHg:** Set the desired Low and High limits that would define Blood Pressure related unwanted intraoperative events. If the measured MAP value surpasses these thresholds, an unwanted event would be counted.
- **Heart Rate (ECG) /min:** Set the desired Low and High limits that would define Heart Rate related unwanted intra-operative events. If the measured HR value surpasses these thresholds, an unwanted event would be counted.

Set the duration, so that the low limit needs to stay below the configured threshold to count as a Hypotension unwanted event (duration only applies to the low limit). Both non-invasive and invasive mean arterial blood pressure data is considered to identify hypertension and hypotension events.

Nimes University study using Carestation Insights AoA application



Carestation Insights AoA application makes it easy for us to ensure that the teams are using the AoA parameters and that the measured values remain within the desired limits. This enables simple and reproducible audits without human queries, as well as benchmarking.

We were motivated to do this study to improve the adherence of the team to Adequacy of Anesthesia technology and to demonstrate that an increased adherence helps improve patient outcomes after surgery.

Prof. Cuvillon

Head of Department of Anaesthesia
at University Hospital of Nimes, France

It has been demonstrated that low blood pressure values combined with low Entropy or BIS values are associated with an increased risk of complications. This is why in our prospective before-after AoA quality-improvement study 1,025 patients were included (517 before, 508 after) with a specific interest in the incidence of low Entropy values (State Entropy -SE < 40) and hypotension (Mean Arterial Pressure – MAP < 60 mmHg for more than 5 minutes).



PHASE 1

The study was split into 2 cohorts: Cohort 1 with 517 cases was used as a baseline of the current use of Adequacy of Anesthesia parameters and the incidence of unwanted events such as low blood pressures longer than five minutes.

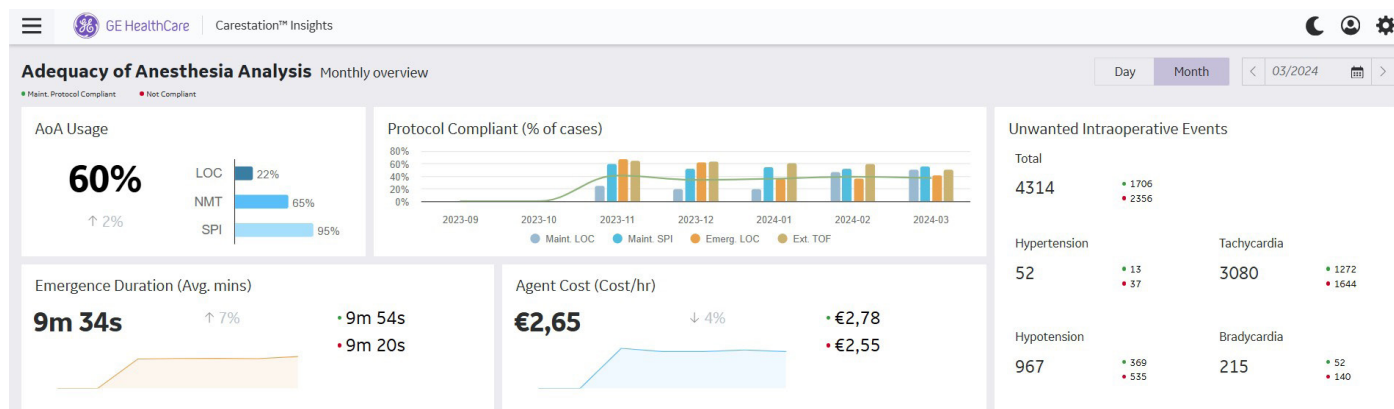


Image 1 Cohort 1. Adequacy of Anesthesia Analysis dashboard representing March 2024 with AoA usage LOC (Level of Consciousness) of 22%

PHASE 2

After educating the team on Entropy and SPI parameters including the Balance View, Cohort 2 included 508 cases. In Cohort 2, we recommend using Entropy and SPI for long-duration surgical procedures and major surgeries. Likewise, elderly patients above 80 years old, which represents 20 to 25% of our patient population, or patients with multiple comorbidities.

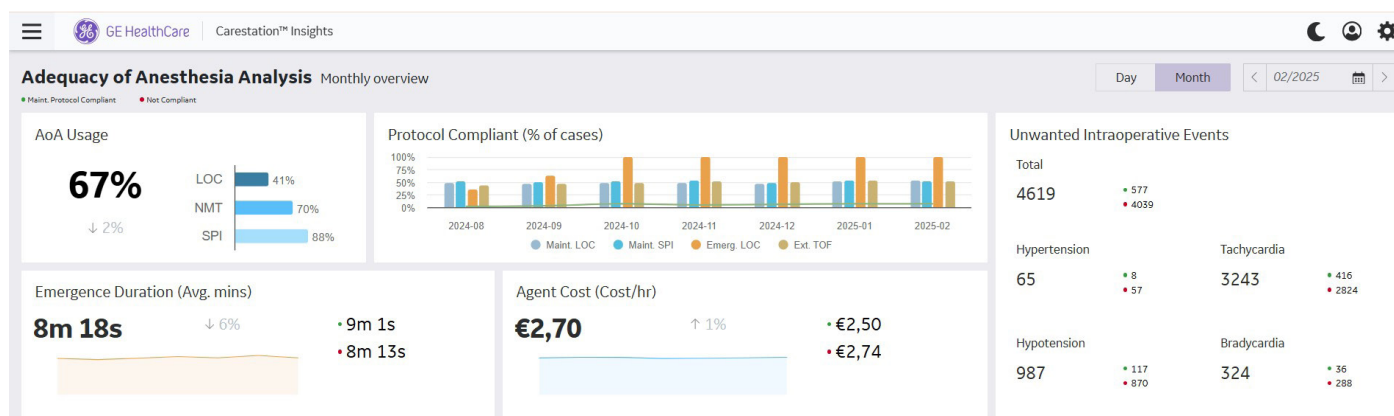


Image 2 Cohort 2. Adequacy of Anesthesia Analysis dashboard representing February 2025 with AoA usage LOC (Level of Consciousness) of 41%

Encourage the change in practices

“We supported and encouraged the change in practices through education, departmental meetings and direct interventions in the operating room carried out by leaders performing anaesthesia alongside their colleagues.”

We shared the AoA dashboard with the entire team to give them transparency and encourage adherence from the team instead of reluctance due to potential lack of confidence. If you share the data, it will be simpler to manage your team. If you don't share the data, the tool will be considered as a big brother.”

Prof. Cuvillon - Head of Department of Anaesthesia at University Hospital of Nimes, France.

RESULTS



In terms of postoperative outcomes, the increased AoA adherence was independently associated with a reduced incidence of Intra Operative Hypotension (IOH), Acute Kidney Injury (AKI), and postoperative pulmonary complications in multivariate analysis. (Table).

Impact of the AoA Training Program on Major Complications (Adjusted Multivariate Analysis)



Outcomes	Adjusted Odds ratio (95 % CI)	P value
IOH (MAP < 60mmHg)	0.45 [0.22 - 0.89]	0.024
Respiratory complications	0.44 [0.20 - 0.92]	0.034
AKI (KDIGO stage 3)	0.23 [0.08 - 0.59]	0.004

Results after the study

“When Dr. Yann Gricourt presented the study results, our anaesthesia team immediately focused on the potential to reduce postoperative complications and wanted more time to observe these patient outcome benefits. This was clearly their main priority. Today, when clinicians see a Burst Suppression Rate (BSR) above 0 or a very low Entropy value, they reduce volatile agent delivery rather than administering additional opioids. I believe the study increased their confidence in the Entropy and SPI values they use every day.”

Prof. Cuvillon - Head of Department of Anaesthesia at University Hospital of Nimes, France.

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