APPLIGUIDE:

Quick Picks for automated low flow anaesthesia with Aisys CS²

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Contents

Introduction

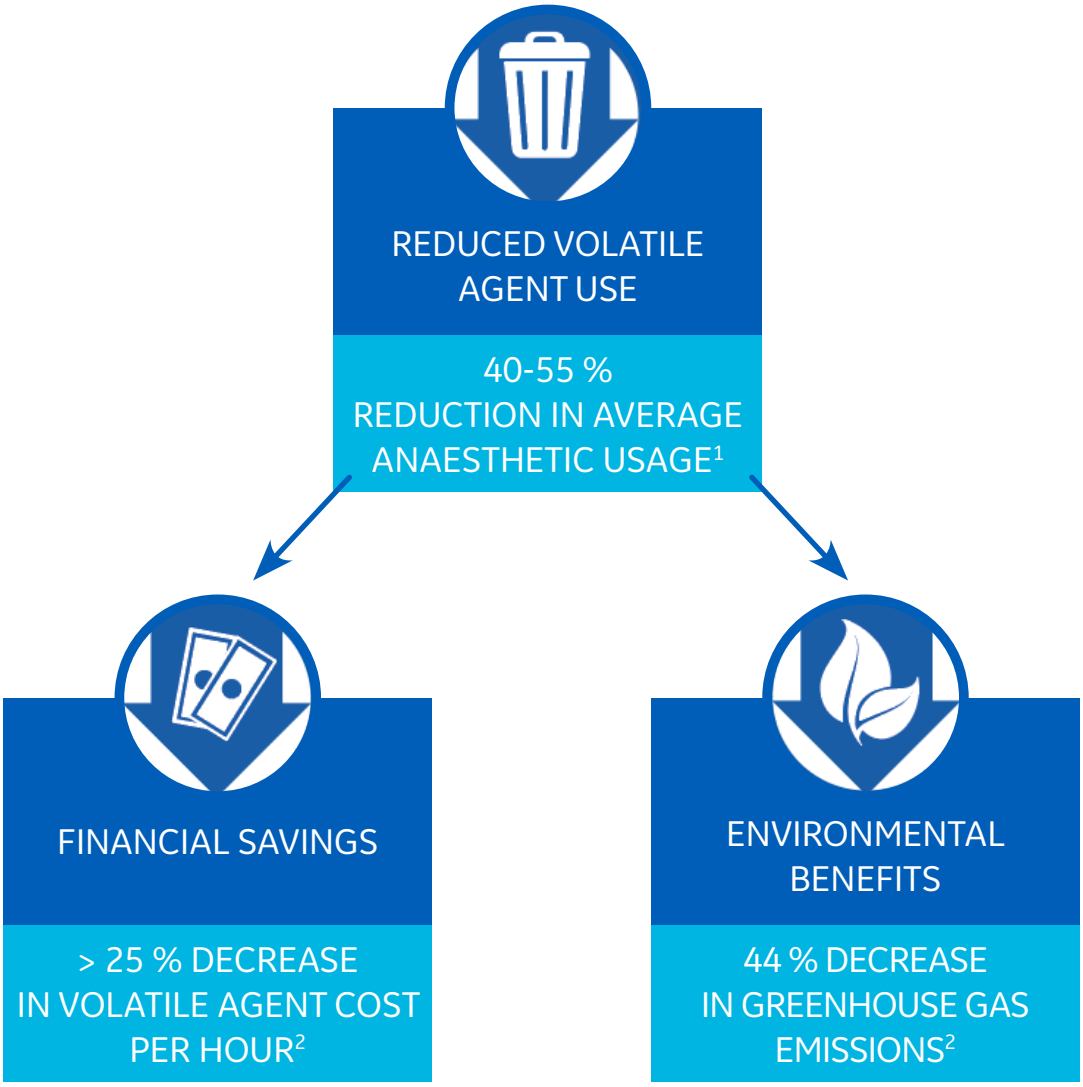
The scope of this appliguide is to explain how clinicians may use automated low flow anaesthesia with Aisys™ CS[2] and select different target end-expired concentrations, helping them to ensure the correct anaesthetic depth during specific stages of a surgical procedure.

This appliguide has been developed in cooperation and with the supervision of Dr Jan Hendrickx from OLV Hospital, Aalst in Belgium and Alumni Consulting Assistant Professor at Stanford University, Stanford, CA.

Why consider low flow anaesthesia?

The term 'low flow' anaesthesia refers to the use of a fresh gas flow (FGF) of 1 l/min. Minimal flow corresponds to 0.5 l/min, while closed circuit anaesthesia is when FGF matches the sum of uptake by the patient, allowing for leaks and sampling by the gas analyser (modern anaesthesia machines redirect these through a circular system to minimise losses). In reality, a wide range of FGFs is used, with the average being 2 l/min.

There are several advantages to reducing FGF to below 2 l/min. Firstly, it reduces anaesthetic waste and therefore cost; waste of inhaled agents increases proportionally when FGF rises above closed circuit anaesthesia conditions. More recently too, there has been a surge in environmental concern over this waste, because inhaled agents are fluorocarbons known to contribute to global warming. Finally, lowering FGF causes more exhaled CO_2 to interact with the CO_2 absorbent, a reaction that produces heat and water that then warms and humidifies the inhaled gases.



Why consider *automating* low flow anaesthesia?

Despite the well-known and clear advantages of using low flow, anaesthetists are still reluctant to use FGFs below 2 l/min in their everyday practice. This is because rebreathing alters the relationship between the vaporiser setting selected and the concentration the patient inspires. This difference becomes particularly prominent with FGFs below 2 l/min.

Choosing which vaporiser setting to use to maintain the right end-expired concentration when the FGF is well below 1 l/min is further complicated by the fact that:

- vaporiser variability is increased (making it a bit more difficult to predict the vaporiser setting in the individual patient)
- it is necessary to continually adjust the vaporiser, especially during the first 15 minutes when uptake decreases rapidly (which happens to coincide with the busy induction period).

The concentrations of carrier gases are affected in the same way – the dialled (delivered or fresh gas) concentration will no longer match that of the inspired gas. Air/O_2 mixtures delivered at concentrations well above 21 % may still cause inspired hypoxic mixtures to form due to the accumulation of N_2. By analogy, the fall in N_2O uptake will cause F_IN_2O to increase at the expense of O_2. In addition, N_2O will have a pronounced effect on the vaporiser setting required to maintain the desired end-expired concentration. Finally, the use of low FGF will delay the effect of a change in vaporiser setting on the end-expired concentration, which will start to oscillate, a property inherent to feedback systems and especially pronounced during manual control.

The clinical implications are obvious; under- and overdosing is bound to result, and the ergonomic burden to the anaesthetist in that first 15 minutes rises. More attention needs to be paid to monitoring the fluctuating end-expired concentrations, and the vaporiser and FGF settings (both total FGF and composition) have to be adjusted accordingly to maintain the stability of the required gas concentrations. This is especially true during this period, when changes are most pronounced but time needs to be prioritised to other things. However, this is also a particularly important time for minimising waste, because even a few minutes of a combination of high vaporiser setting and high FGF can result in a significant amount of waste. Things become even more demanding if you intentionally seek to rapidly alter the end-expired concentration during different phases of the procedure.

Automated low flow anaesthesia offers clear advantages:

SIMPLIFIED MANAGEMENT OF FRESH GAS FLOW AND VOLATILE AGENTS[2]

REDUCED BURDEN AND WORKLOAD FOR ANAESTHETISTS

>50 % DECREASE IN MACHINE INTERACTION PER PATIENT [1,3]

MORE TIME FOR OTHER PATIENT NEEDS AND OPERATING ROOM ACTIVITIES[2,3]

PEACE OF MIND FOR AVOIDING POTENTIAL HYPOXIA AND UNDER OR OVER-DOSING VOLATILE AGENTS[2,3]

An easy way to automate low flow anaesthesia during different stages of the procedure

Automating low flow anaesthesia is not just about minimising agent waste, but is also a way to solve the clinical challenge of titrating end-expired concentrations to the specific depths required throughout the different phases of an anaesthetic – the 'peaks and troughs' of anaesthesia.

One example of this is the immediate post-induction phase prior to incision, where there is no need to rapidly increase the end-expired concentration to surgical levels. Targeting an end-expired concentration of 0.6 MAC at this point takes into account the combination of:

- falling propofol and sufentanil levels
- the delay between the end-expired concentration and that in the effect site (the brain)
- drug interactions between the three drug classes in the absence of a surgical stimulus to ensure hypnosis.[4]

Higher partial pressures of volatile agents during this critical stage of the anaesthetic would increase the risk of hypotension. According to studies,[5,6] approximately 5 % of paediatric and 9 % of adult patients experience significant hypotension 0 to 10 minutes post-induction of general anaesthesia, and this percentage is higher in ASA class III-V patients.

From a practical point of view,[7,8] anaesthetic depth is titrated to achieve three different clinical end-points:

- hypnosis
- immobility – absence of movement in the face of a noxious stimulus
- minimizing the stress response after a noxious stimulus, such as hypertension or tachycardia.

Note, the latter two phases are also referred to as analgesia.

The MAC scale developed by Ted Eger[9] is based on the end-expired concentrations required to reach these clinical end-goals in 50 % of patients in the absence of opioids. Automating low flow anaesthesia by presetting agent targets (Quick Picks) can rapidly attain the different end tidal levels required for these clinical end-goals, while simultaneously minimising agent usage.

Quick Picks defined

Quick Picks is a feature of the GE Healthcare Aisys CS^2 anaesthesia system that allows users to set end tidal targets via a touchscreen, controlling low flow anaesthesia while also offering the opportunity to quickly change anaesthetic depth according to changing clinical conditions.

The choice of inhaled agent (sevoflurane or desflurane) is determined by the agent-specific Aladin cassette inserted into the vaporiser slot of the Aisys CS^2 prior to the start of the anaesthetic procedure (Figure 1).

Figure 1: Inhaled agent selection

This is also confirmed on the touchscreen (Figure 2).

Figure 2: Aisys CS^2 initial touchscreen

At the start of a new procedure, the patient's age is entered to allow the machine to calculate and display the MAC (steps 1 and 2). Selecting 'Start Anaesthesia' (step 3) activates a high O_2 FGF to pre-oxygenate the patient. Following intravenous induction of anaesthesia, the FGF is temporarily discontinued using 'pause' so that the airway can be secured (Figure 3).

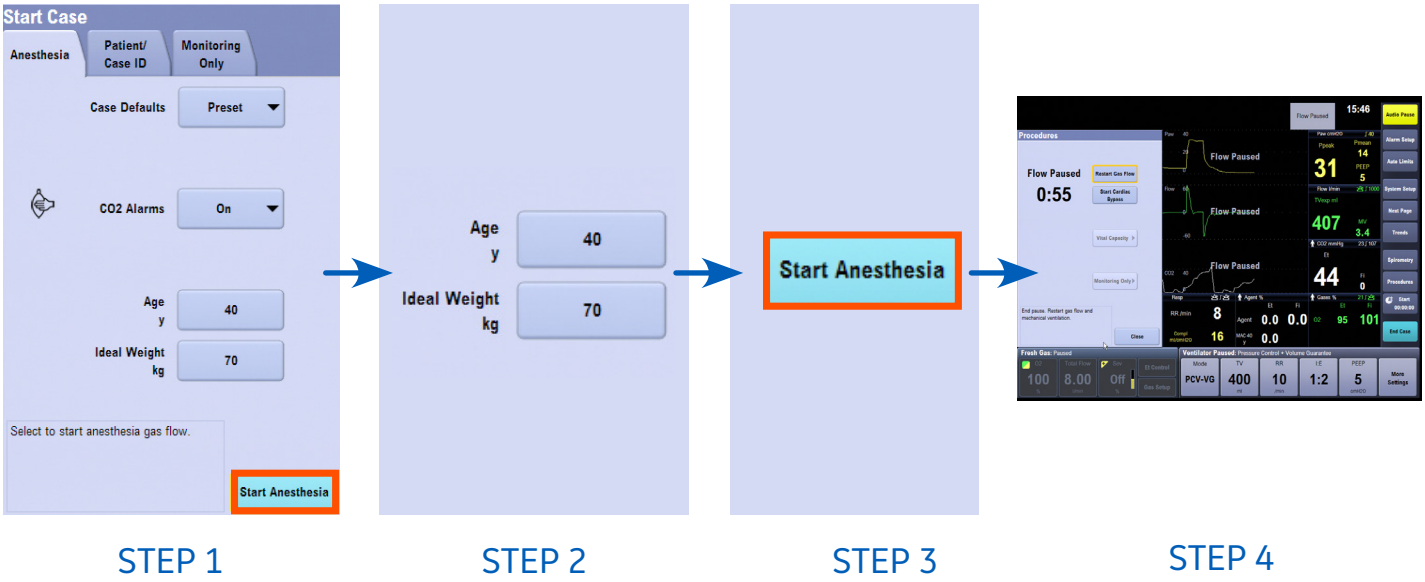


Figure 3: Straightforward steps to induce low flow anaesthesia

After confirming the presence of end-expired CO_2, the ventilatory mode of choice is started. The default carrier gas is O_2/air, but can be changed to O_2/N_2O via the 'Gas Setup' button. At this stage, the agent and carrier gas delivery is still in manual mode. The three tabs in the left lower corner of the screen allow the user (from left to right) to manually control the delivered O_2 %, the FGF, and the delivered agent concentration (Figure 4).

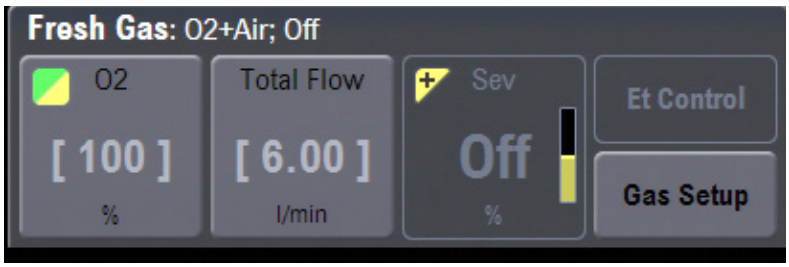


Figure 4: Specifying the ventilatory parameters

After selecting the desired parameters, automatic control is started by pressing ‘Et Control’ followed by ‘Start’ (Figure 5).

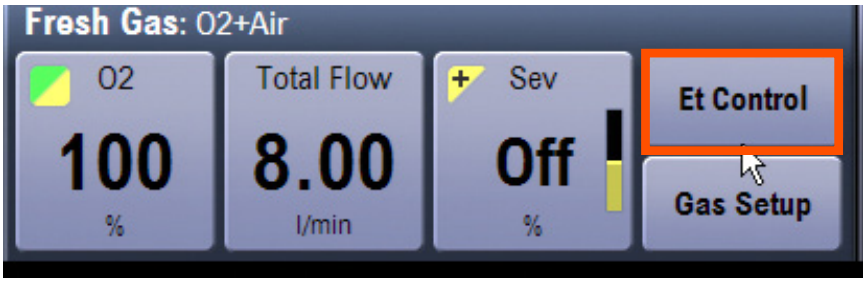


Figure 5: Confirming ventilatory mode selections

The automated mode screen is then displayed (Figure 6).

Figure 6: Automated mode display screen

Two things should be noted. Firstly, the manual mode display of agent and carrier gas has been replaced by the automated ‘Et Control’ mode display, allowing the user to now select (from left to right) target end-expired O_2 %, the minimum FGF, and the target end-expired agent concentration (Figure 7).

Figure 7: Automated FGF setting mode for end tidal control

Secondly, a selection of preset end-expired agent concentrations has appeared (Figure 8).

Figure 8: Preset end-expired agent concentrations

The clinician now has the option to either start selecting the individual targets (option 1: 'Classic' target controlled low flow anaesthesia) or use the Quick Picks presets (option 2: Quick Picks facilitated target controlled low flow anaesthesia).

Option 1: Classic target controlled low flow anaesthesia

End-expired O_2 and agent target concentrations can be selected for the lowest FGF you would like the Aisys CS_2 to deliver (Figure 9). The Aisys CS^2 low flow algorithm will aim for the 'Min Flow' FGF. The FGF and agent delivery will continually change as the Et Control algorithm makes adjustments to achieve the target concentrations, while simultaneously minimising waste. The clinician can adjust the end-expired agent concentration as deemed fit.

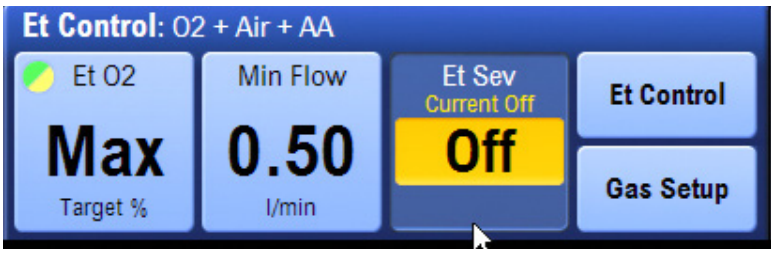


Figure 9: Selecting end-expired O_2 and agent target concentrations

Option 2: Quick Picks facilitated target controlled low flow anaesthesia

Quick Picks supports the concept of low flow anaesthesia by taking everything into consideration, including that:

- the required anaesthetic depth is not constant and so the target end-expired agent concentration has to fluctuate throughout a procedure
- achieving well-defined targets rapidly using manual low flow anaesthesia can be clinically challenging and distracting.

Quick Picks has pre-configured settings to help clinicians rapidly attain different clinical end-goals during different phases of the anaesthetic with a minimum of effort and a minimum of agent waste. The user can select from seven pre-configured targets, five of which are different end-expired anaesthetic agent concentrations, and two combined end-expired O_2 and anaesthetic agent concentrations (Figure 10).

Figure 10: Choice of Quick Picks pre-configured targets for automated low flow anaesthesia

How to optimally use the Quick Picks pre-configured target concentrations

The choice of Quick Pick setting relates to the progressive increase in end-expired agent concentration (and so anaesthetic depth) required to provide hypnosis, immobility, blunting of the stress response (analgesia), and to the interaction with opioids to achieve each of these clinical end-goals. This can be best explained using the inhaled agent-opioids data from Katoh[10,11] and Hendrickx[12] (Figure 11).

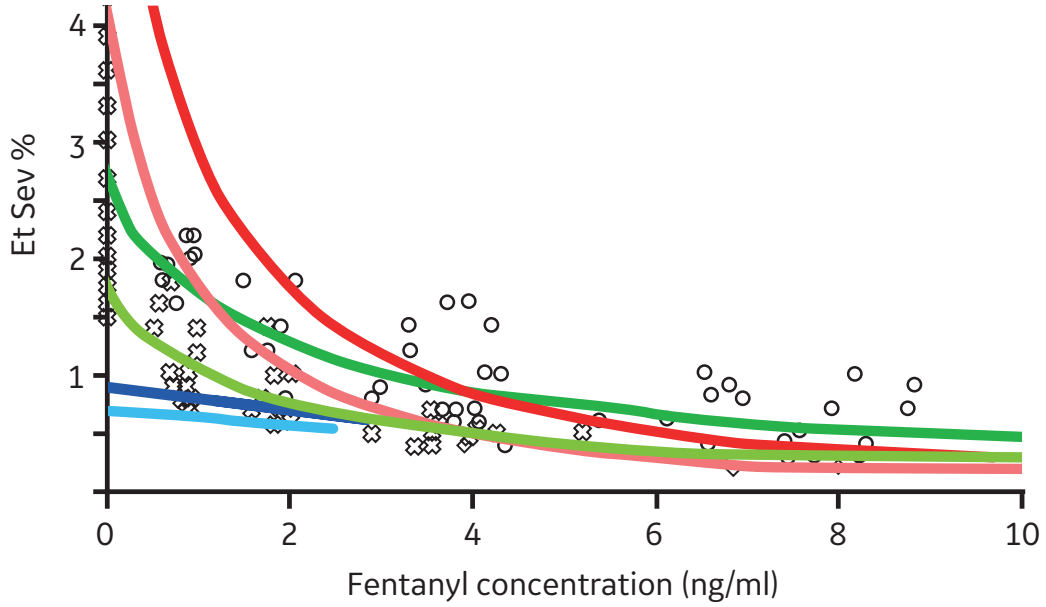


Figure 11: Inhaled agent-opioids interaction curves

The coloured lines (isoboles) represent similar depths of anaesthesia. From a pragmatic point of view, increasing anaesthetic depth can be defined as moving from the blue to the green and red lines. The blue lines represent all possible inhaled agent and opioid concentrations that ensure 50 (light blue) or 95 % (dark blue) of the patients are unconscious in the absence of a surgical stimulus. The green lines represent all those combinations that ensure 50 (light green) or 95 % (dark green) of the patients remain immobile after surgical incision (if muscle relaxants were not to be used) and unconscious in the absence of a surgical stimulus. The red lines represent all those combinations that ensure autonomic stress response control in 50 (light red) or 95 % (red) of the patients.

The Quick Picks presets all meet or exceed the 95 % target isoboles representing the different stages of anaesthesia in the anaesthetic range most commonly used (Figure 12).

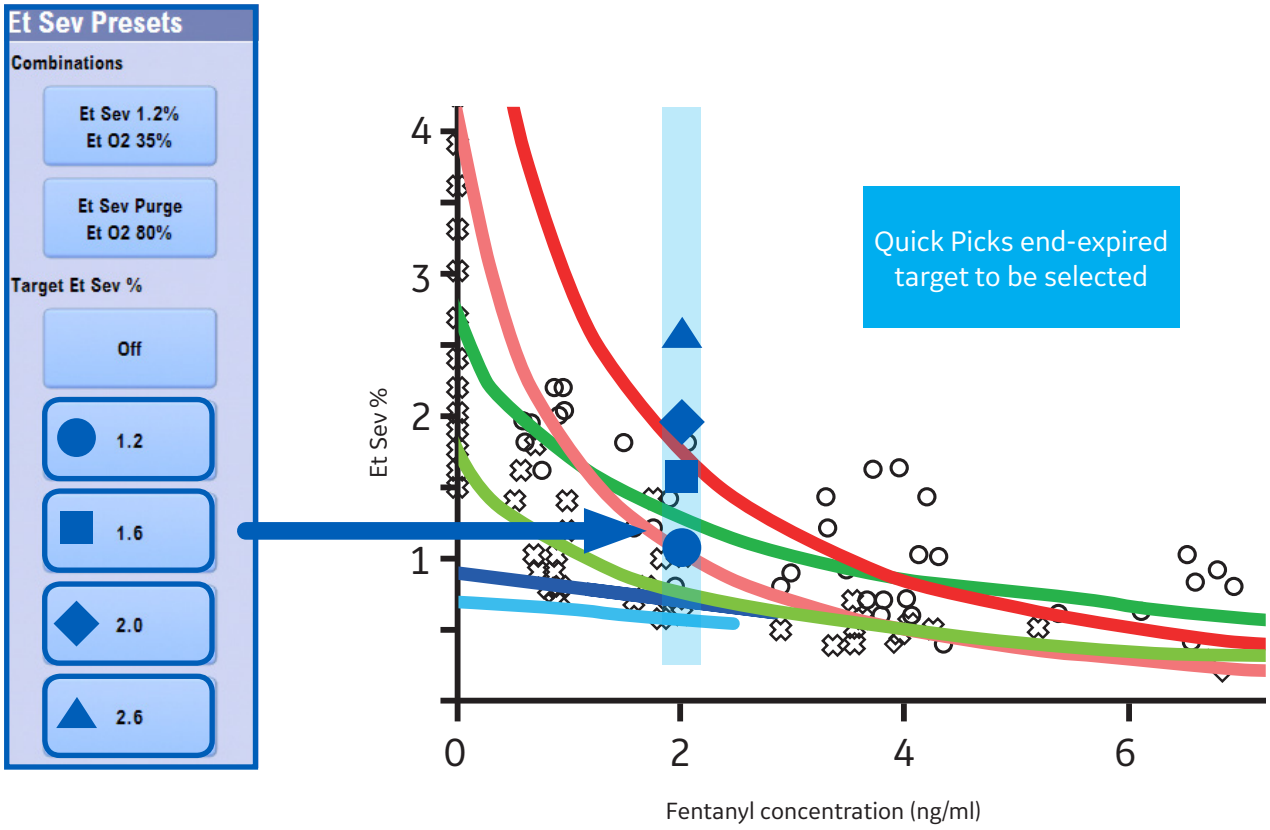
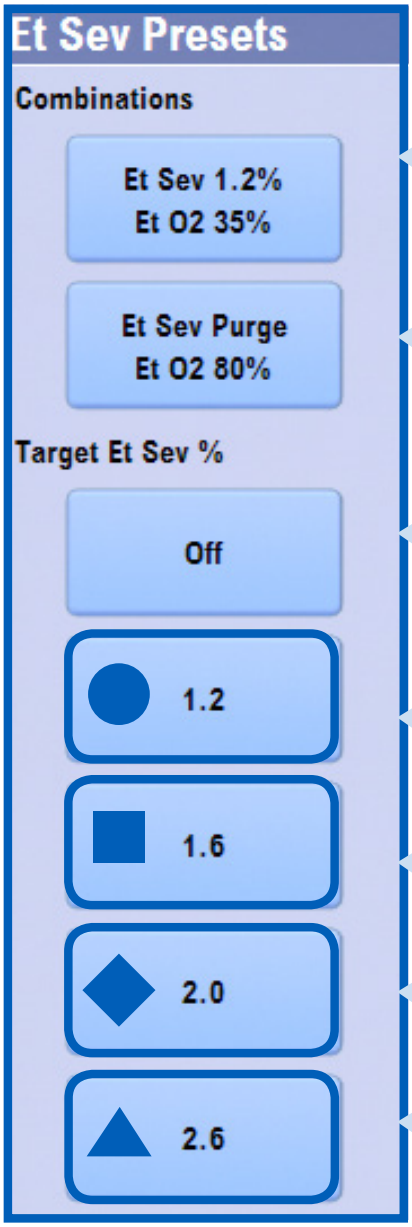


Figure 12: Quick Picks presets and their corresponding locations on Katoh's graph shown here as an example for 2ng/ml fentanyl, O_2/air

How and when clinicians might use each Quick Picks pre-configured setting



When: after IV induction and while awaiting incision; towards the end of a case (taper)
Goal: to ensure hypnosis while minimising hypotension
0.6 MAC sufficient to ensure hypnosis if opioid and residual propofol effects are considered
Ergonomics: one touch only for O_2 and agent selection

When: end of case, when fast alveolar wash-out is desired
Goal: to initiate FGF>MV to avoid rebreathing; fast response
80 % O_2 minimises atelectasis
Ergonomics: one touch only and machine increases FGF and stops agent delivery

When: to discontinue agent delivery – FGF does not change
Goal: slow alveolar wash-out at end of procedure (tapering)
Hysteresis decreases: end-expired % close to CNS effect site %
If titrated towards MAC awake (to be carefully monitored), emergence will be rapid once agent is washed out with a high FGF. Some extra agent savings (can maintain sufficient depth for a while)

When: after IV induction, awaiting surgical incision; towards end of procedure (taper)
Goal: to attain hypnosis while minimising hypotension
0.6 MAC is sufficient to ensure hypnosis if opioid and residual propofol effects are considered

When: a few minutes prior to surgical incision (three-minute wash-in and hysteresis)
Goal: to attain hypnosis, immobility and stress response blunting, if opioids are added
Point of maximum synergy according to Katoh

When: intense surgical stimulus expected
Goal: to ensure immobility without muscle relaxants (if opioids are added)

When: intense stress response to be blunted
(alternative: more opioids, vasoactive drugs)

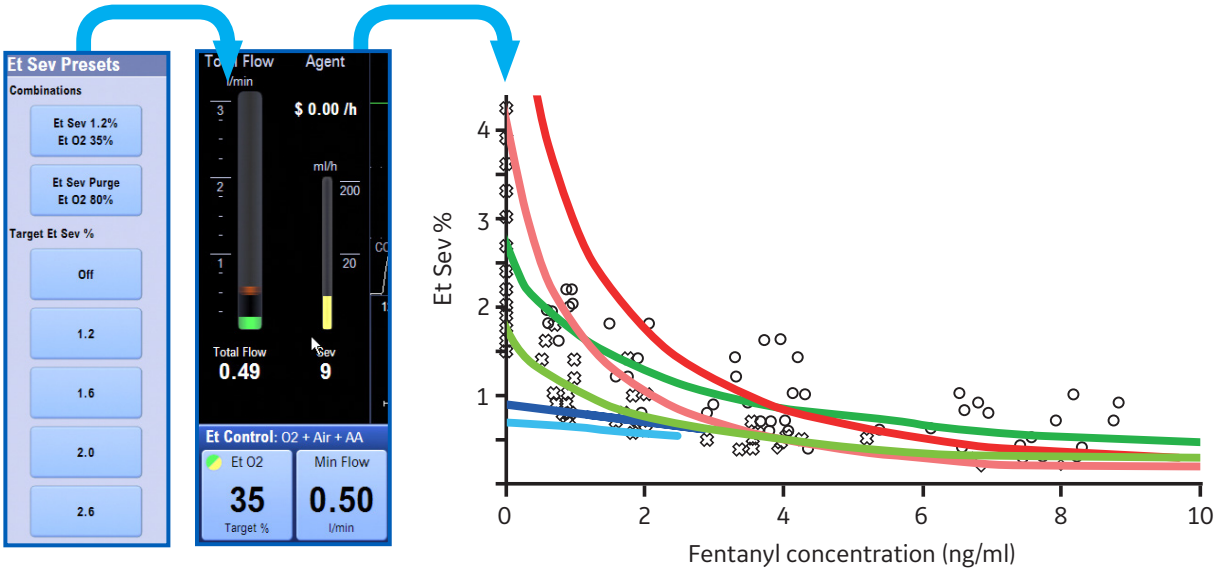
Figure 13: The rationale for choosing different target Et Sev % at the various stages to improve anaesthesia workflow

Quick Picks does not define the target end-goals; that is the responsibility of the anaesthetist, who should use the proposed value only if using similar conditions as in this guide (balanced anaesthesia with volatile agents and opioids, without the use of N_2O). Any deviation from said conditions should be taken into account to adapt the target levels saved as Quick Picks. Additionally, anaesthetists should titrate target levels used according to the clinical effects, such as:

- by monitoring MAC displayed in the monitor
- by observing monitoring tools for haemodynamics and depth of anaesthesia
- by taking prior drug dosing of hypnotics and opioids into account
- by adjusting for the use of N_2O
- by taking hysteresis into account between the end-expired and effect site (CNS) concentration

Summary

Automated low flow anaesthesia empowered by preset agent targets (Quick Picks) can rapidly attain the different end tidal levels required for the right depth of anaesthesia as judged by the anaesthetist. Quick Picks allows clinicians to rapidly, smoothly and ergonomically use automated low flow anaesthesia, allowing them to match the pharmacological depth of anaesthesia to changing clinical conditions. This may improve clinical workflow and avoid over- and under-dosing of hypnotics.



Improved ergonomics	**Reduced waste**	**Fast to target**	**Appropriate anaesthetic depth, titrated to and integrated with workflow**

By automating the delivery of the inhaled agent towards a certain end tidal target, it is possible to get straight on the desired target. The burden of manually adjusting vaporisers and accounting for all the oscillations is removed, and the desired depth of anaesthesia is obtained faster and more precisely.

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Imagination at work

End Tidal Control (EtC) is not commercially available in all markets.
Not cleared or approved by the U.S. FDA

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