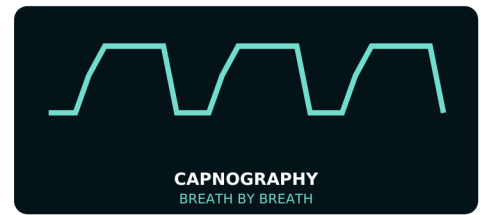


BRIEF 003 • MONITORING • ~7 MIN READ

Capnography: The Vital Sign We're Underusing



WRITTEN BY

Claudia Elizabeth Goward & Phil Baker
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THE CLINICAL QUESTION

Why do we reserve capnography for the sickest patients when it may show deterioration before they become the sickest?

Capnography is familiar territory in cardiac arrest and advanced airway management. Outside those settings, however, its use is often less consistent.

That matters because the waveform can provide breath-by-breath information about ventilation and clues about perfusion, metabolism, airway obstruction and equipment failure. In some patients, the capnogram may change while oxygen saturation still appears reassuring.

This creates a wider role for capnography than simply confirming an airway or recording an ETCO_2 value. Used alongside the rest of the assessment, the waveform can help clinicians recognise changing physiology, question an apparently reassuring set of observations and identify deterioration that may not yet be obvious from the patient's SpO_2 alone.

The important question is not whether capnography is useful. It is whether we are using it early enough, and interpreting it carefully enough, to add meaningful information to the clinical picture.

THEORY • PRACTICE • BEYOND

THEORY

WHAT DOES THE CAPNOGRAM ACTUALLY SHOW?

Capnometry is the numerical measurement of exhaled carbon dioxide; capnography adds the waveform over time. ETCO₂ is the carbon dioxide measured at the end of expiration. In healthy physiology it usually tracks below arterial PaCO₂, but the gradient changes with dead space and ventilation-perfusion mismatch and can widen substantially in critical illness (Long, Koyfman and Vivirito, 2017; Hong et al., 2025).

That makes ETCO₂ a physiological signal rather than a non-invasive arterial blood gas. Carbon dioxide must be produced by metabolism, transported to the lungs by circulation and removed by ventilation. A change in any of those processes - or in the airway, circuit or sampling system - can alter the trace (Nassar and Schmidt, 2022). The same ETCO₂ value can therefore arise from very different mechanisms.

Read the waveform before the number

An isolated ETCO₂ value invites classification as normal, high or low. The waveform adds context. Frequency reflects detected breaths; morphology can suggest altered expiratory emptying, rebreathing or interruption of sampling; and serial change can reveal evolving physiology (Long, Koyfman and Vivirito, 2017).

But waveform findings are rarely specific. Loss of a previously credible trace may result from apnoea, tube displacement, obstruction, circuit disconnection, sampling failure or a major fall in pulmonary blood flow. Likewise, low tidal volumes, movement and equipment problems can distort measurement (Long, Koyfman and Vivirito, 2017). Capnography is therefore strongest when it triggers reassessment rather than when it is treated as a diagnosis.

This is the first critical step: decide whether the trace is credible before deciding what it means.

A breath has a shape

A typical time capnogram moves from a near-zero inspiratory baseline through an expiratory upstroke to an alveolar plateau, with ETCO₂ measured at the end of expiration. Failure to return towards baseline can occur with rebreathing, while a sloping expiratory phase may accompany airflow obstruction (Long, Koyfman and Vivirito, 2017).

The familiar 'shark-fin' waveform is useful pattern recognition, but it should not become another shortcut. A 2025 systematic review of 11 studies in acute asthma found that some ETCO₂ and waveform measures were associated with admission or treatment response, but correlations with established clinical markers were generally weak or absent. The authors concluded that further prognostic-accuracy research is needed (Farshid et al., 2025). In other words: the waveform may add information, but clinical severity still has to be assessed clinically.

Why SpO₂ may be late

SpO₂ and capnography answer different questions. Pulse oximetry describes arterial oxygen saturation; capnography displays exhaled CO₂ breath by breath. Supplemental oxygen can therefore maintain a reassuring saturation while ventilation deteriorates.

Fu et al. (2004) tested this directly. In 45 anaesthetised patients subjected to deliberate hypoventilation, SpO₂ fell in those breathing room air but remained stable in those receiving supplemental oxygen; a second randomised recovery-room cohort included 288 patients. This is peri-operative rather than prehospital evidence, so it should not be over-generalised, but the physiological lesson is directly relevant: oxygen saturation can be a late signal of hypoventilation when oxygen is being administered.

More recently, Català Altarriba et al. (2025) prospectively studied 101 children undergoing procedural sedation. This sits within a wider evidence base: systematic reviews and meta-analyses have generally found that adding capnography during procedural sedation reduces hypoxaemic/desaturation events, although study populations, definitions and methodological quality vary (Conway, Douglas and Sutherland, 2016; Saunders et al., 2017; Kim et al., 2018; Askar et al., 2020). Capnography detected all recorded apnoea episodes and identified respiratory events a median 35 seconds earlier than pulse oximetry when both modalities detected the event. The study was single-centre and did not demonstrate improved patient-centred outcomes, but it supports

the principle that capnography and SpO₂ are complementary rather than interchangeable.

PRACTICE

WHERE DOES CAPNOGRAPHY CHANGE CARE?

1. Advanced airway confirmation

This is the strongest indication. Resuscitation Council UK (2025) recommends waveform capnography to confirm tracheal tube placement during CPR and to monitor CPR quality. The ERC 2025 ALS guideline gives the same recommendation (Soar et al., 2025).

The value is continuous confirmation, not a single successful trace after intubation. If a previously established waveform disappears, tube position, airway patency, circuit integrity, sampling and circulation all require immediate reassessment. The trace identifies change; it does not identify the cause.

2. Respiratory depression

Evidence for respiratory-depression monitoring is strongest in sedation and anaesthesia rather than routine ambulance populations. Meta-analyses of randomised procedural-sedation trials generally show fewer hypoxaemic events when capnography is added to standard monitoring, but the evidence is heterogeneous and is not direct evidence of benefit in unsedated ambulance patients (Conway, Douglas and Sutherland, 2016; Saunders et al., 2017; Kim et al., 2018; Askar et al., 2020). UK Association of Anaesthetists guidance recommends capnography during procedural sedation whenever there is loss of response to verbal contact (Klein et al., 2021). Català Altarriba et al. (2025) also demonstrated earlier recognition of respiratory events during paediatric sedation.

There is prehospital evidence too, although it is older and observational. Kober et al. (2004) evaluated non-intubated emergency patients in the prehospital environment and concluded that capnography provided additional respiratory monitoring alongside pulse oximetry. That supports selective use in patients at risk of hypoventilation, but it does not justify claiming that every opioid-exposed or reduced-consciousness patient requires capnography.

3. Cardiac arrest

During CPR, exhaled CO₂ is influenced partly by pulmonary blood flow generated by chest compressions. Systematic-review evidence shows higher ETCO₂ values are associated with ROSC, but the underlying evidence is observational and low quality, with substantial confounding; this supports trends as additional physiological information rather than a stand-alone prognostic rule (Paiva et al., 2018a; Paiva et al., 2018b). RCUK 2025 recommends waveform capnography to monitor CPR quality and states that an increase in ETCO₂ may indicate ROSC, but compressions should not be interrupted on this sign alone (Resuscitation Council UK, 2025). ERC 2025 likewise recommends waveform capnography for tube confirmation and CPR-quality monitoring (Soar et al., 2025).

The limitation is important: ventilation, airway technique, drugs, arrest aetiology and measurement conditions all influence ETCO₂. RCUK explicitly warns that low ETCO₂ alone must not be used to decide that resuscitation should be stopped (Resuscitation Council UK, 2025). Capnography adds physiology to the arrest; it does not reduce prognosis to a threshold.

4. Obstructive airway disease

Obstructive physiology can alter the expiratory waveform, producing the recognisable sloping phase III. The temptation is to treat that morphology as a severity score. Current evidence does not support that simplification.

The 2025 systematic review in acute asthma found that lower ETCO₂ and several waveform measures showed associations with admission or treatment response in some studies, but correlations with other markers of obstruction were often weak (Farshid et al., 2025). This makes capnography potentially useful as an adjunct, not a replacement for respiratory effort, auscultation, respiratory rate, oxygenation, peak flow where appropriate and response to treatment.

5. The ventilated patient

Continuous capnography can expose changes in breath delivery, airway patency and circuit integrity during assisted ventilation. UK anaesthesia standards require waveform capnography during general anaesthesia and continuation while an artificial airway remains in place (Klein et al., 2021).

The danger is chasing a universal ETCO₂ target. In 1,978 mechanically ventilated critically ill patients, a wider PaCO₂-ETCO₂ gradient was associated with greater illness severity and mortality, illustrating how strongly critical illness and V/Q mismatch can disrupt the relationship between arterial and end-tidal CO₂ (Hong et al., 2025). ETCO₂ should therefore inform ventilation strategy, not be mistaken for PaCO₂.

6. During movement and transfer

Transfers create predictable opportunities for unnoticed change: patients are repositioned, disconnected and reconnected, loaded into vehicles and observed in noisy environments. A continuous waveform can make loss of ventilation or circuit interruption immediately visible.

Klein et al. (2021) recommend capnography during transfer of anaesthetised or sedated patients when an airway device remains in place. That is strong UK monitoring guidance, but it is not ambulance-specific outcome evidence. Applying the same principle to prehospital transport is clinically plausible; it should be presented as extrapolation rather than proof that routine capnography improves outcomes during every transfer.

BEYOND

Why is it still treated as an advanced-airway monitor?

Capnography entered many clinicians' practice through airway and resuscitation training, so it is unsurprising that its strongest mental association remains 'tube confirmation'. Prehospital observational evidence also suggests ETCO₂ may carry information about perfusion in trauma: lower prehospital values have been associated with mortality, although these studies are prognostic rather than evidence that ETCO₂-guided treatment improves outcomes (Childress et al., 2018). Yet published evidence describes useful applications in spontaneously breathing patients, procedural sedation, ventilation and critical illness as well as cardiac arrest (Long, Koyfman and Vivirito, 2017; Nassar and Schmidt, 2022).

The critical distinction is evidence strength. RCUK and ERC provide explicit recommendations in advanced life support. UK anaesthesia guidance provides clear standards in anaesthesia, sedation and transfer. Broader emergency and respiratory applications are supported by a mixture of observational studies, physiological reasoning, reviews and emerging systematic-review evidence. Those are not equivalent levels of certainty.

JRCALC should remain the clinical-practice framework for UK ambulance care (JRCALC, 2022). Where local/JRCALC guidance does not mandate capnography for a particular presentation, evidence about broader utility should support - not bypass - clinical judgement and organisational policy.

The danger of chasing 35-45

A familiar reference range can become an anchor. ETCO₂ depends on CO₂ production, ventilation, pulmonary perfusion, dead space and sampling. Critical illness can markedly widen the arterial-to-end-tidal gradient (Hong et al., 2025).

A low ETCO₂ may reflect hyperventilation, reduced perfusion, increased dead space or technical sampling; a high value may reflect hypoventilation, increased CO₂ production or rebreathing (Long, Koyfman and Vivirito, 2017). The number therefore needs a mechanism. 'Why is this value occurring in this patient, and how is it changing?' is usually more useful than simply asking whether it sits between 35 and 45 mmHg.

Capnography creates questions - not answers

This is both the strength and limitation of the monitor. A disappearing waveform may represent airway, circuit, sampling or circulatory failure. A rising ETCO₂ may reflect reduced ventilation, improved perfusion or increased CO₂ production. The same monitor finding can therefore demand very different management (Nassar and Schmidt, 2022).

Long, Koyfman and Vivirito (2017) conclude that capnography should be interpreted alongside other patient factors and clinical assessment. That principle is more important than memorising waveform labels: the trace should narrow the questions you ask, not close the differential.

Start with the change

When the capnogram changes, assess the patient and the system in parallel. Recheck consciousness, respiratory effort, respiratory rate, chest movement and perfusion; then check the airway device, circuit, connections, sampling line and monitor. Only once the signal is credible should the ETCO₂ trend be interpreted physiologically (Long, Koyfman and Vivirito, 2017).

This sequence deliberately resists anchoring on the displayed number. It asks whether the change reflects ventilation, circulation, metabolism, treatment, position or equipment - and whether the rest of the clinical picture supports that explanation.

THE TAKEAWAY

Use the trace to notice change earlier

These questions are designed to stop ETCO₂ becoming another isolated observation. They combine technical validation, waveform interpretation, trend analysis and clinical context - principles consistently emphasised in monitoring guidance and emergency-medicine reviews (Klein et al., 2021; Long, Koyfman and Vivirito, 2017).

1. Is there a credible waveform? Confirm that the trace is consistent and the sampling system is connected before attributing a change to physiology.

2. What is the respiratory rate and pattern? Look for slowing, tachypnoea, pauses, irregularity or apnoea rather than relying on ETCO₂ alone.

3. What is the shape telling me? Use morphology as supportive evidence for altered emptying, rebreathing, leak or obstruction - not as a diagnosis in isolation.

4. What is the trend? Direction and response to treatment may be more informative than one isolated value.

5. Does it fit the patient? Relate the trace to work of breathing, consciousness, perfusion, SpO₂ and the wider clinical picture.

6. What else could explain the change? Actively check airway, circuit, sampling, ventilation, circulation and equipment before settling on one interpretation.

BEYOND THE BRIEF

Connect it before the patient looks like they need it

The strongest evidence for capnography remains in airway management, cardiac arrest, anaesthesia and sedation. But those settings demonstrate a broader principle: ventilation can change before oxygen saturation makes deterioration obvious, and continuous waveform monitoring can expose that change (Fu et al., 2004; Català Altarriba et al., 2025).

For prehospital practice, the evidence supports selective rather than indiscriminate use. The opioid-exposed patient, the sedated or reduced-consciousness patient, the tiring respiratory patient, the ventilated patient and a transfer where airway or ventilation changes could be difficult to see are all reasonable situations in which a credible waveform may add context (Kober et al., 2004; Long, Koyfman and Vivirito, 2017).

The evidence does not show that attaching capnography to every patient improves outcomes. It shows that, in the right clinical setting, the trace can reveal information that SpO₂ and intermittent observation do not provide. The monitor cannot make the decision. It can sometimes make the change visible sooner - and give the clinician more time to decide what that change means.

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ABOUT THE AUTHORS

Claudia Elizabeth Goward

Claudia is a paramedic with an interest in evidence-based practice, clinical reasoning and the context in which prehospital decisions are made. She is particularly interested in how research and guidance translate into the reality of patient care, where complexity, uncertainty and individual circumstances matter.

Phil Baker

Phil is a paramedic with an interest in clinical education, evidence-based practice and the practical application of research in prehospital care. He is particularly interested in how clinicians interpret evidence, make decisions under pressure and adapt structured guidance to the patient in front of them.

Together

Claudia and Phil are the co-founders of The Prehospital Brief, an independent clinical education and evidence platform created by paramedics for prehospital professionals. Their work focuses on looking beyond protocols alone - exploring the evidence, context and clinical reasoning that help shape better care.

EVIDENCE NOTE

Evidence was prioritised from peer-reviewed primary research, systematic reviews, meta-analyses and major UK/European guidance. The evidence base is not uniform across indications: RCUK/ERC recommendations are the clearest practice guidance for advanced airway management and cardiac arrest; sedation evidence is largely drawn from anaesthesia and procedural-sedation populations; and broader respiratory/prehospital applications remain less certain. JRCALC is included as the UK ambulance clinical-practice framework, but this Brief does not attribute a capnography-specific JRCALC recommendation where the underlying guideline text has not been independently verified.

Educational disclaimer. The Prehospital Brief provides educational discussion of evidence relevant to prehospital practice. It does not replace JRCALC or other local clinical guidelines, organisational policy, individual clinical judgement or appropriate senior clinical advice.