Nutrition in Clinical Practice

Are Classic Bedside Exam Findings Required to Initiate Enteral Nutrition in Critically ill Patients: Emphasis on Bowel Sounds and Abdominal Distension

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Abstract:	<p>The general physical examination of a patient is an axiom of critical care medicine but evidence to support this practice remains sparse. Given the lack of evidence for a comprehensive physical examination on admission to the intensive care unit, which most clinicians consider an essential part of care, should clinicians continue the practice of gastrointestinal system physical examination when commencing enteral nutrition in the critically ill?</p> <p>In this review of literature related to gastrointestinal system examination in the critically ill, the focus is on gastrointestinal sounds and abdominal distension. There is a summary of what these physical features represent, an evaluation of the evidence regarding use of these physical features in patients after abdominal surgery, exploration of the rationale for and against using the physical findings in routine practice, and detail regarding what is known about each feature in the critically ill.</p> <p>Based on the available evidence it is recommended that an isolated symptom, sign or bedside test does not provide meaningful information. However, it is submitted that a comprehensive assessment still has a role when initiating or administering enteral nutrition: specifically, when multiple features are present, clinicians should consider further investigation or intervention.</p>

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ABSTRACT

The general physical examination of a patient is an axiom of critical care medicine but evidence to support this practice remains sparse. Given the lack of evidence for a comprehensive physical examination on admission to the intensive care unit, which most clinicians consider an essential part of care, should clinicians continue the practice of gastrointestinal system physical examination when commencing enteral nutrition in the critically ill?

In this review of literature related to gastrointestinal system examination in the critically ill, the focus is on gastrointestinal sounds and abdominal distension. There is a summary of what these physical features represent, an evaluation of the evidence regarding use of these physical features in patients after abdominal surgery, exploration of the rationale for and against using the physical findings in routine practice, and detail regarding what is known about each feature in the critically ill.

Based on the available evidence it is recommended that an isolated symptom, sign or bedside test does not provide meaningful information. However, it is submitted that a comprehensive assessment still has a role when initiating or administering enteral nutrition: specifically, when multiple features are present, clinicians should consider further investigation or intervention.

INTRODUCTION

A physical examination of a patient complements information obtained from the history of presenting illness or injury, and assists with the formulation of potential diagnoses to inform further investigations ¹⁻³. Whilst a fundamental axiom of clinical medicine, there remains a lack of published data that the physical examination of the entire patient improves outcomes for critically ill patients ⁴. Nonetheless, in addition to comprehensive examination on admission, a daily clinician examination of the patient is considered a cornerstone of caring for the critically ill ⁵.

In ambulant patients the focussed physical examination of the gastrointestinal system traditionally includes inspection, palpation, percussion and auscultation ⁶. In the critically ill, interpretation of the gastrointestinal tract physical examination findings is more challenging because of limited patient feedback ⁷. In the intensive care unit the gastrointestinal system examination relies on inspection and percussion to identify abdominal distension ⁸, palpation for focal tenderness to identify discrete pathologies such as acalculous cholecystitis or generalised tenderness for perforated viscus ⁹, and auscultation to identify the presence of sounds arising from the gastrointestinal tract - or so called 'bowel sounds' ¹⁰.

The provision of enteral nutrition is recommended for critically ill patients ¹¹⁻¹³. However, gastrointestinal dysmotility occurs frequently in critically ill patients ¹⁴, leading to enteral feed intolerance or other signs of gastrointestinal dysfunction in up to one third of patients ¹⁵⁻¹⁷. How then should physical signs influence the decision to initiate, or continue, enteral nutrition in the critically ill?

In this review there is a focus on two physical signs – auscultation for gastrointestinal sounds and inspection and percussion to identify abdominal distension – as part of a comprehensive assessment of the gastrointestinal system (Figure 1). This review submits that such assessment should occur prior to initiating enteral nutrition and as part of ongoing daily assessment in the intensive care unit.

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However, there are gastrointestinal symptoms, such as vomiting, constipation (perhaps more precisely termed absence of defecation), and diarrhoea as well as simple bedside tests – including residual gastric volume, intra-abdominal pressure and blood lactate – that are not covered in this review. Whilst the details of these other clinical tools are beyond the scope of this review, updated literature reviews on these topics can be found elsewhere ¹⁸⁻²².

It should be recognised that performing a comprehensive assessment prior to initiation of enteral nutrition, as well as daily assessment whilst delivering enteral nutrition to the critically ill, may reduce the total ‘dose’ of nutrition delivered to a proportion of patients ²³. However, there remains uncertainty as to what comprises optimal nutrition therapy at the population level ²⁴⁻²⁷. Accordingly, it seems improbable that reducing the dose of nutrition for an individual patient based on a comprehensive assessment will cause harm ²⁸⁻³⁰. Furthermore, it is intuitively plausible that an approach to incorporate physical examination findings may be beneficial by optimising nutrient delivery to the individual and/or effecting early identification of ominous gut pathologies ^{31,32}.

Gastrointestinal dysmotility during critical illness and postoperative ileus share many pathogenic features ³³. Given the greater number of studies evaluating the role of gastrointestinal examination in patents with postoperative ileus, a review of this pathology is included to provide relevant insights. For each physical examination feature, i.e. gastrointestinal sounds and abdominal distension, a summary is provided for:

- (i) What the physical feature represents?
- (ii) The use of the examination finding in patients after abdominal surgery.
- (iii) The rationale for and against using the physical finding in routine practice.
- (iv) What is known about the examination feature in the critically ill?

Gastrointestinal sounds

What do gastrointestinal sounds represent?

Sound is produced when a force causes an object or substance to vibrate, with the energy transferred through sound waves. In 1905 Cannon first reported auscultation of gastrointestinal sounds³⁴. Gastrointestinal sounds occur because of the transfer of energy arising from gastrointestinal tract motility.

In health, the motor function of the gastrointestinal tract is categorised in either the fasting or fed state. Fasting motility is divided into three phases; each phase having typical contractile features within the gastrointestinal tract. These three phases are termed the migratory motor complex and occur in a cyclical fashion; phase I is characterised by quiescent motor pattern, phase II by irregular motor contraction and phase III by periods of regular contractions³⁵.

In a series of elegant experiments, Tomomasa and colleagues established that, at least in health, gastrointestinal sounds represent the energy transferred during intraluminal propulsion that occurs during late fasting phase II of the migratory motor complex³⁶. The duration of each phase of the migratory motor complex varies substantially between individuals; however in fasted healthy volunteers the mean ($\pm$ SEM) duration of phase I (the quiescent phase) is reported to be 23 ± 4 minutes³⁷. This prompted Tomomasa and colleagues to suggest that clinicians who want to precisely quantify gastrointestinal sounds should listen for 20 minutes, or for shorter periods at intervals of 20-25 minutes³⁶.

The use of gastrointestinal sounds as a clinical sign in patients after abdominal surgery

In patients presenting to hospital, auscultation of gastrointestinal sounds was traditionally thought to assist with diagnosing acute gastrointestinal pathologies^{38,39}. However, the clinical utility of auscultating the abdomen has been challenged by a number of studies involving healthy volunteers or patients after major surgery⁴⁰⁻⁴⁴. Indeed, there is only weak agreement between clinicians when

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identifying whether gastrointestinal sound recordings are from healthy volunteers or patients with pathologies ⁴². The weak inter-rater reliability of gastrointestinal auscultation may reflect the short period of observation ⁴⁵.

Read and colleagues observed 124 patients after major abdominal surgery at a single centre ⁴³. In this study gastrointestinal sounds were detected in 40% of patients on postoperative day 0, increasing to 88% by day 4 ⁴³. However, the presence of gastrointestinal sounds was not associated with passing of flatus, bowel movement or tolerance of oral intake ⁴³. Recommendations that comprise the enhanced recovery after surgery (ERAS) program include early initiation of enteral nutrition without waiting for gastrointestinal sounds ⁴⁶. Moreover, even in patients who develop postoperative ileus, expert consensus opinion is that auscultation for gastrointestinal sounds is of limited to no use ⁴⁷. Finally, a recent systematic review of randomised clinical trials evaluating ileus post gastrointestinal surgery identified 217 randomised clinical trials, with only 21 (< 10%) reporting time to detect gastrointestinal sounds and no trials having time to detect gastrointestinal sounds as the primary outcome ⁴⁸. Taken together, these data suggest that as a single physical feature, auscultation for gastrointestinal sounds provides negligible meaningful information when caring for patients with postoperative ileus.

An inadequate duration of observation may explain why auscultation for gastrointestinal sounds is of limited value in identifying postoperative ileus ⁴³. Experts have suggested that technology could augment any benefits of auscultation by allowing prolonged recordings, signal enhancement to identify more sounds, and machine learning to interpret these sounds ⁴⁹. Using such technology, a study of 40 participants (25 with postoperative ileus, 7 patients tolerating enteral nutrition and 8 healthy controls) at a single centre reported that patients with postoperative ileus produced substantially less acoustic data than those without ileus, and those without ileus produced substantially less acoustic data than healthy volunteers during a 60 min period of monitoring ⁵⁰. This group then conducted a subsequent longitudinal study using the same technology in 28 patients at 2

hospitals after major abdominal surgery and reported that acoustic data during prolonged monitoring was less in patients with postoperative ileus⁵¹.

The rationale for auscultating for gastrointestinal sounds in the critically ill

The rationale for including abdominal auscultation in routine practice when caring for the critically ill includes that univariate analysis reveals associations between absence of gastrointestinal sounds and mortality^{52,53}. However, severity of illness and other concomitant symptoms are confounding variables, with gastrointestinal sounds less likely to be heard in more severely ill patients. Within observational data sets researchers attempt to adjust for severity of illness using acute physiology scores, e.g. APACHE or SOFA, however these are crude adjustments that do not account for many additional factors such as sedation or analgesia. Fasting critically ill patients spend a greater proportion of time in phase I of the migrating motor complex, and late phase II and III motor activity is infrequent⁵⁴⁻⁵⁶. As described above, gastrointestinal sounds occur during intraluminal propulsion in late phase II. Accordingly, those auscultating for gastrointestinal sounds during critical illness should expect lesser periods of gastrointestinal sounds than in ambulant populations because many of the treatments administered in the intensive care unit, such as analgesic and sedative drugs, attenuate gastrointestinal motility^{57,58}.

Auscultation may have some negative predictive value, i.e. hearing gastrointestinal sounds means that the critically ill patient is less likely to have dysmotility. However, retrograde peristalsis or bowel movement proximally from obstructed bowel also produce sounds^{42,44,59,60}.

What do we know about gastrointestinal sounds as a clinical sign in the critically ill?

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Survey data suggest auscultation of the abdomen is far from a universal examination technique with ≈80% of the surveyed 2298 critical care nurses in the United States reporting that they used this method ^{61,62}. Observational studies also indicate that wide variation in practice remains even when the abdomen is auscultated, with no single methodology regularly implemented ⁶³⁻⁶⁵.

The European Society of Intensive Care Medicine (ESICM) Working Group on Abdominal Problems (2012) has provided recommendations on gastrointestinal auscultation and the implications of gastrointestinal sounds as one component of physical examination ¹⁰. It should be emphasised that these recommendations are based solely on expert opinion. The expert opinion was that clinicians listen for at least one minute in two quadrants repeated once ¹⁰ and that the absence of gastrointestinal sounds was considered abnormal ¹⁰. However, the *“presence of bowel sounds does not confirm normal motility, and reoccurrence of bowel sounds does not correlate with improvement of paralysis. There are no special management suggestions for absent/abnormal bowel sounds ¹⁰.”* Indeed, it is plausible that the absence of gastrointestinal sounds does not represent pathology. Indeed, because a period of quiescence is normal, particularly in the critically ill, an absence of gastrointestinal sounds during a short period of observation without any additional symptoms, signs or abnormal bedside tests, should not identify gastrointestinal dysfunction, nor trigger any management decisions.

Given that a greater duration of observation in postoperative ileus is more informative than a shorter period, there is face validity in assuming auscultation for longer periods may be more beneficial. It is possible that technology could assist with prolonged monitoring ⁶⁶. A small proof of concept study evaluating the feasibility of prolonged monitoring was recently published ⁶⁷. Gunto and colleagues attached 4 acoustic sensors to the abdomen of 5 critically ill patients who required mechanical ventilation and were able to record gastrointestinal sounds for more than 24 hours in each patient ⁶⁷.

Abdominal distension

What does abdominal distension represent?

Abdominal distension has been defined as a sagittal abdominal diameter that is greater than the rib cage or hip height ⁶⁸. However, this definition only refers to volume with no consideration of pressure generated by the change in volume ⁶⁹. This is important as abdominal distension is pathognomonic when increased pressure is present but is of lesser importance when the volume increase occurs without any pressure change.

Traditional teaching is that causes of distension begin with the letter 'F'; i.e. fat (obesity), fluid (ascites), foetus, flatus (gaseous distension), faeces or 'filthy' big tumour ⁷⁰. Whether, and to which extent, a certain increase in volume causes augmentation of pressure is dependent on abdominal compliance ⁷¹. In ambulant patients a rapid increase in intra-abdominal volume is usually due to fermentation of dietary or endogenous substrates within the large bowel lumen, which are the major sources of gas production ⁷². Several factors related to critical illness contribute to rapid increase in intra-abdominal volume and increased pressure. These include tissue oedema, ascites and intraluminal gas or fluid due to motility disturbances, maldigestion and malabsorption.

The use of abdominal distension as a clinical sign in patients after abdominal surgery

Inspection of the abdomen in the immediate postoperative period is important to detect complications (e.g. bleeding). Identification of abdominal distension in this phase should prompt investigations to exclude bleeding (e.g. measurement of haemoglobin and/or imaging). However, palpation and percussion is more challenging in the immediate postoperative phase, is observer-dependent and does not afford quantification for repeat comparison. Measurement of intra-abdominal pressure may allow quantification and comparison over time and can be considered in patients developing abdominal distension after major abdominal surgery or trauma ^{73,74}. Intra-

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abdominal pressure measurement can assist with identification of abdominal compartment syndrome, a life-threatening consequence of abdominal distension of any aetiology, that requires definitive intervention rather than just increasing organ support within the intensive care unit ^{75,76}. However, interpretation of dynamics of intra-abdominal pressure requires adaption for abdominal compliance and any pressure value must be considered relative to the patient, the surgery completed and other organ dysfunction ^{71,77}.

In the later postoperative course, bowel distension, commonly along with bowel paralysis, is the main cause of abdominal distension. For some institutions that are familiar with intra-abdominal pressure monitoring (Figure 2), repeat intra-abdominal pressure monitoring over time can provide dynamic information and trigger further imaging. Importantly, imaging may only reveal dimensions of the bowel without quantifying the internal pressure applied to the bowel wall. Therefore, radiology findings commonly refer to bowel dilatation, whereas distension is a clinical diagnosis (pressure being commonly associated with discomfort/pain/tenderness) ⁶⁹.

The rationale for abdominal distension as a clinical sign in the critically ill

Gastrointestinal dysmotility is frequently associated with abdominal distension ¹⁴. Clinical examination to differentiate increased volume from pathognomic distension (increased volume and pressure) is challenging in the ICU, particularly in patients receiving sedation, analgesia and muscle relaxant. However, clinically identified abdominal distension is associated with intra-abdominal hypertension ⁶⁵.

Digestion and absorption of carbohydrates and lipids can be impaired in the critically ill ⁷⁸⁻⁸¹. Accordingly, this may result in modest increases in abdominal girth without symptoms – i.e. increase in volume without additional symptoms, signs or tests that suggest corresponding increase in pressure – that may be initially treated with variation in supply of carbohydrate or lipid to the colon

81-83. Fermentation of an endogenous substrate may also be due to slow colonic transit or changes in the microbiome, which may respond to specific intervention to stimulate defecation or increasing the diversity in the microbiome 83-88.

However, an increase in volume with additional symptoms, signs or bedside tests indicative of an increase in pressure – e.g. pain, absence of bowel motions, profuse diarrhoea, tenderness, hyperlactatemia and increased gastric residual volume – should trigger further investigations, monitoring or intervention.

What is known about using abdominal distension as a clinical sign in the critically ill?

In several cohort studies conducted in the critically ill abdominal distension has been included as a sign of pathology in several cohort studies 52,65. However, in previous studies abdominal distension was identified either with a subjective clinical assessment, where pressure was also present, or by an enlargement of bowel identified radiologically. Whilst intra-abdominal pressure was measured in many of the patients, intra-abdominal hypertension was included as an additional and separate physical feature. The majority of patients with 3 or more concomitant gastrointestinal symptoms had intra-abdominal hypertension 64. None of these studies report an association between an isolated physical feature of abdominal or bowel distension and death. However, when distension was incorporated with other features, then the presence of 3 or more gastrointestinal symptoms was independently associated with increased mortality 64. Accordingly, abdominal distension may provide important information as part of a comprehensive clinical assessment until reliable bedside monitoring tools become available.

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Enteral nutrition remains a component of routine care ^{11,29} and the authors recommend against waiting for gastrointestinal sounds prior to starting enteral nutrition. Similarly there are no data to suggest daily cursory auscultation *per se* to decide whether enteral nutrition will be of benefit. However, when auscultation is a component of a more comprehensive assessment of gastrointestinal function, and the presence or absence of gastrointestinal sounds is incorporated with other examination features and simple bedside tests auscultation probably has an additive role.

If an increase in abdominal volume occurs without additional features, clinicians can consider a reduction in carbohydrate load, strategies to increase the diversity of the microbiome or measurement of intra-abdominal pressure. None of these interventions are, however, supported by unequivocal data from randomised clinical trials. Intra-abdominal pressure may be useful when there is uncertainty about the need for additional investigation/s that require transport out of the intensive care unit or an intervention that is associated with more than negligible risk.

Whether decisions based on such complex assessment of a constellation of imprecise symptoms, signs and test results improve outcomes remains untested. However, without a proven alternative, it is the opinion of the authors that the use of minimally-invasive and inexpensive assessment methodologies is better than abandoning routine assessment of gastrointestinal function. Because excessively aggressive administration of enteral nutrition may cause harm ³¹, a daily evaluation with early identification of serious events such as non-obstructive bowel ischemia and critical bowel distension with life-threatening perforation should continue as part of routine care.

Given this, the use of technology to allow prolonged periods of minimally invasive observation, with presence and characteristics of gastrointestinal sounds validated using objective criteria, warrants further evaluation. This technology may be particularly useful in cohorts of patients for whom clinicians remain uncertain about whether to initiate or increase enteral nutrition, such as those with hypotension requiring considerable vasopressor support or profound hypoxia or acidosis ^{11,13,31,32,89}.

Future studies should also produce data that informs when to initiate intra-abdominal pressure monitoring and what interventions are effective once intra-abdominal hypertension is identified.

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Figure captions:

Figure 1. Bedside assessment of the gastrointestinal tract

Figure 2. Intra-abdominal pressure is measured in the supine, paralysed patient at end-expiration via a transducer in continuity with the bladder, zeroed at the mid-axillary line. 25ml of fluid is instilled in the empty bladder and the pressure taken after 60 seconds.

For Peer Review

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ABSTRACT

The ~~evidence to support any~~ general physical examination of a ~~critically ill~~ patient is an axiom of critical care medicine but evidence to support this practice remains sparse. Given the lack of evidence for a comprehensive physical examination on admission to the intensive care unit, which most clinicians consider an essential part of care~~Should, therefore, should~~ clinicians continue the practice of gastrointestinal system physical examination when commencing enteral nutrition in the critically ill?

In this review of literature related to gastrointestinal system examination in the critically ill, the focus is on gastrointestinal sounds and abdominal distension. There is a summary of what these physical features represent, an evaluation of the evidence regarding use of these physical features in patients after abdominal surgery, exploration of the rationale for and against using the physical findings in routine practice, and detail regarding what is known about each feature in the critically ill.

Based on the available evidence it is recommended that an isolated symptom, sign or bedside test does not provide meaningful information. However, it is submitted that a comprehensive assessment still has a role when initiating or administering enteral nutrition: specifically, when multiple features are present, clinicians should consider further investigation or intervention.

INTRODUCTION

A physical examination of a patient complements information obtained from the history of presenting illness or injury, and assists with the formulation of potential diagnoses to inform further investigations ¹⁻³. Whilst a fundamental axiom of clinical medicine, there remains a lack of published data that the physical examination of the entire patient improves outcomes for critically ill patients ⁴. Nonetheless, in addition to comprehensive examination on admission, a daily clinician examination of the patient is considered a cornerstone of caring for the critically ill ⁵.

In ambulant patients the focussed physical examination of the gastrointestinal system traditionally includes inspection, palpation, percussion and auscultation ⁶. In the critically ill, interpretation of the gastrointestinal tract physical examination findings is more challenging because of limited patient feedback ⁷. In the intensive care unit the gastrointestinal system examination relies on inspection and percussion to identify abdominal distension ⁸, palpation for focal tenderness to identify discrete pathologies such as acalculous cholecystitis or generalised tenderness for perforated viscus ⁹, and auscultation to identify the presence of sounds arising from the gastrointestinal tract - or so called 'bowel sounds' ¹⁰.

The provision of enteral nutrition is recommended for critically ill patients ¹¹⁻¹³. However, gastrointestinal dysmotility occurs frequently in critically ill patients ¹⁴, leading to enteral feed intolerance or other signs of gastrointestinal dysfunction in up to one third of patients ¹⁵⁻¹⁷. How then should physical signs influence the decision to initiate, or continue, enteral nutrition in the critically ill?

In this review **there is a** focus on two physical signs – auscultation for gastrointestinal sounds and inspection and percussion to identify abdominal distension – as part of a comprehensive assessment of the gastrointestinal system (Figure 1). **This review submits** that such assessment should occur prior to initiating enteral nutrition and as part of ongoing daily assessment in the intensive care unit.

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However, there are gastrointestinal symptoms, such as vomiting, constipation (perhaps more precisely termed absence of defecation), and diarrhoea as well as simple bedside tests – including residual gastric volume, intra-abdominal pressure and blood lactate – that are not covered in this review. Whilst the details of these other clinical tools are beyond the scope of this review, updated literature reviews on these topics can be found elsewhere ¹⁸⁻²².

It should be recognised that performing a comprehensive assessment prior to initiation of enteral nutrition, as well as daily assessment whilst delivering enteral nutrition to the critically ill, may reduce the total ‘dose’ of nutrition delivered to a proportion of patients ²³. However, there remains uncertainty as to what comprises optimal nutrition therapy at the population level ²⁴⁻²⁷. Accordingly, it seems improbable that reducing the dose of nutrition for an individual patient based on a comprehensive assessment will cause harm ²⁸⁻³⁰. Furthermore, it is intuitively plausible that an approach to incorporate physical examination findings may be beneficial by optimising nutrient delivery to the individual and/or effecting early identification of ominous gut pathologies ^{31,32}.

Gastrointestinal dysmotility during critical illness and postoperative ileus share many pathogenic features ³³. Given the greater number of studies evaluating the role of gastrointestinal examination in patents with postoperative ileus, a review of this pathology is included to provide relevant insights. For each physical examination feature, i.e. gastrointestinal sounds and abdominal distension, a summary is provided for:

- (i) What the physical feature represents?
- (ii) The use of the examination finding in patients after abdominal surgery.
- (iii) The rationale for and against using the physical finding in routine practice.
- (iv) What is known about the examination feature in the critically ill?

Gastrointestinal sounds

What do gastrointestinal sounds represent?

Sound is produced when a force causes an object or substance to vibrate, with the energy transferred through sound waves. In 1905 Cannon first reported auscultation of gastrointestinal sounds³⁴. Gastrointestinal sounds occur because of the transfer of energy arising from gastrointestinal tract motility.

In health, the motor function of the gastrointestinal tract is categorised in either the fasting or fed state. Fasting motility is divided into three phases; each phase having typical contractile features within the gastrointestinal tract. These three phases are termed the migratory motor complex and occur in a cyclical fashion; phase I is characterised by quiescent motor pattern, phase II by irregular motor contraction and phase III by periods of regular contractions³⁵.

In a series of elegant experiments, Tomomasa and colleagues established that, at least in health, gastrointestinal sounds represent the energy transferred during intraluminal propulsion that occurs during late fasting phase II of the migratory motor complex³⁶. The duration of each phase of the migratory motor complex varies substantially between individuals; however in fasted healthy volunteers the mean ($\pm$ SEM) duration of phase I (the quiescent phase) is reported to be 23 ± 4 minutes³⁷. This prompted Tomomasa and colleagues to suggest that clinicians who want to precisely quantify gastrointestinal sounds should listen for 20 minutes, or for shorter periods at intervals of 20-25 minutes³⁶.

The use of gastrointestinal sounds as a clinical sign in patients after abdominal surgery

In patients presenting to hospital, auscultation of gastrointestinal sounds was traditionally thought to assist with diagnosing acute gastrointestinal pathologies^{38,39}. However, the clinical utility of auscultating the abdomen has been challenged by a number of studies involving healthy volunteers or patients after major surgery⁴⁰⁻⁴⁴. Indeed, there is only weak agreement between clinicians when

identifying whether gastrointestinal sound recordings are from healthy volunteers or patients with pathologies ⁴². The weak inter-rater reliability of gastrointestinal auscultation may reflect the short period of observation ⁴⁵.

Read and colleagues observed 124 patients after major abdominal surgery at a single centre ⁴³. In this study gastrointestinal sounds were detected in 40% of patients on postoperative day 0, increasing to 88% by day 4 ⁴³. However, the presence of gastrointestinal sounds was not associated with passing of flatus, bowel movement or tolerance of oral intake ⁴³. Recommendations that comprise the enhanced recovery after surgery (ERAS) program include early initiation of enteral nutrition without waiting for gastrointestinal sounds ⁴⁶. Moreover, even in patients who develop postoperative ileus, expert consensus opinion is that auscultation for gastrointestinal sounds is of limited to no use ⁴⁷. Finally, a recent systematic review of randomised clinical trials evaluating ileus post gastrointestinal surgery identified 217 randomised clinical trials, with only 21 (< 10%) reporting time to detect gastrointestinal sounds and no trials having time to detect gastrointestinal sounds as the primary outcome ⁴⁸. Taken together, these data suggest that as a single physical feature, auscultation for gastrointestinal sounds provides negligible meaningful information when caring for patients with postoperative ileus.

An inadequate duration of observation may explain why auscultation for gastrointestinal sounds is of limited value in identifying postoperative ileus ⁴³. Experts have suggested that technology could augment any benefits of auscultation by allowing prolonged recordings, signal enhancement to identify more sounds, and machine learning to interpret these sounds ⁴⁹. Using such technology, a study of 40 participants (25 with postoperative ileus, 7 patients tolerating enteral nutrition and 8 healthy controls) at a single centre reported that patients with postoperative ileus produced substantially less acoustic data than those without ileus, and those without ileus produced substantially less acoustic data than healthy volunteers during a 60 min period of monitoring ⁵⁰. This group then conducted a subsequent longitudinal study using the same technology in 28 patients at 2

hospitals after major abdominal surgery and reported that acoustic data during prolonged monitoring was less in patients with postoperative ileus⁵¹.

The rationale for auscultating for gastrointestinal sounds in the critically ill

The rationale for including abdominal auscultation in routine practice when caring for the critically ill includes that univariate analysis reveals associations between absence of gastrointestinal sounds and mortality^{52,53}. However, severity of illness and other concomitant symptoms are confounding variables, with gastrointestinal sounds less likely to be heard in more severely ill patients. Within observational data sets researchers attempt to adjust for severity of illness using acute physiology scores, e.g. APACHE or SOFA, however these are crude adjustments that do not account for many additional factors such as sedation or analgesia. Fasting critically ill patients spend a greater proportion of time in phase I of the migrating motor complex, and late phase II and III motor activity is infrequent⁵⁴⁻⁵⁶. As described above, gastrointestinal sounds occur during intraluminal propulsion in late phase II. Accordingly, those auscultating for gastrointestinal sounds during critical illness should expect lesser periods of gastrointestinal sounds than in ambulant populations because many of the treatments administered in the intensive care unit, such as analgesic and sedative drugs, attenuate gastrointestinal motility^{57,58}.

Auscultation may have some negative predictive value, i.e. hearing gastrointestinal sounds means that the critically ill patient is less likely to have dysmotility. However, retrograde peristalsis or bowel movement proximally from obstructed bowel also produce sounds^{42,44,59,60}.

What do we know about gastrointestinal sounds as a clinical sign in the critically ill?

Survey data suggest ~~wide variation between clinicians as to whether they~~ auscultation of the abdomen is far from a universal examination technique with ≈80% of the surveyed 2298 critical care nurses in the United States reporting that they used this method^{61,62}. Observational studies also indicate that wide variation in practice remains even when the abdomen is auscultated, with no single methodology regularly implemented⁶³⁻⁶⁵.

The European Society of Intensive Care Medicine (ESICM) Working Group on Abdominal Problems (2012) has provided recommendations on gastrointestinal auscultation and the implications of gastrointestinal sounds as one component of physical examination¹⁰. It should be emphasised that these recommendations are based solely on expert opinion. The expert opinion was that clinicians listen for at least one minute in two quadrants repeated once¹⁰ and that the absence of gastrointestinal sounds was considered abnormal¹⁰. However, the *“presence of bowel sounds does not confirm normal motility, and reoccurrence of bowel sounds does not correlate with improvement of paralysis. There are no special management suggestions for absent/abnormal bowel sounds¹⁰.”* Indeed, it is plausible that the absence of gastrointestinal sounds does not represent pathology. Indeed, because a period of quiescence is normal, particularly in the critically ill, an absence of gastrointestinal sounds during a short period of observation without any additional symptoms, signs or abnormal bedside tests, should not identify gastrointestinal dysfunction, nor trigger any management decisions.

Given that a greater duration of observation in postoperative ileus is more informative than a shorter period, there is face validity in assuming auscultation for longer periods may be more beneficial. It is possible that technology could assist with prolonged monitoring⁶⁶. A small proof of concept study evaluating the feasibility of prolonged monitoring was recently published⁶⁷. Gunto and colleagues attached 4 acoustic sensors to the abdomen of 5 critically ill patients who required mechanical ventilation and were able to record gastrointestinal sounds for more than 24 hours in each patient⁶⁷.

Abdominal distension

What does abdominal distension represent?

Abdominal distension has been defined as a sagittal abdominal diameter that is greater than the rib cage or hip height ⁶⁸. However, this definition only refers to volume with no consideration of pressure generated by the change in volume ⁶⁹. This is important as abdominal distension is pathognomonic when increased pressure is present but is of lesser importance when the volume increase occurs without any pressure change.

Traditional teaching is that causes of distension begin with the letter 'F'; i.e. fat (obesity), fluid (ascites), foetus, flatus (gaseous distension), faeces or 'filthy' big tumour ⁷⁰. Whether, and to which extent, a certain increase in volume causes augmentation of pressure is dependent on abdominal compliance ⁷¹. In ~~the community ambulant patients~~ a rapid increase in intra-abdominal volume is usually due to fermentation of dietary or endogenous substrates within the large bowel lumen, which are the major sources of gas production ⁷². Several factors related to critical illness contribute to rapid increase in intra-abdominal volume and increased pressure. These include tissue oedema, ascites and intraluminal gas or fluid due to motility disturbances, maldigestion and malabsorption.

The use of abdominal distension as a clinical sign in patients after abdominal surgery

Inspection of the abdomen in the immediate postoperative period is important to detect complications (e.g. bleeding). Identification of abdominal distension in this phase should prompt investigations to exclude bleeding (e.g. measurement of haemoglobin and/or imaging). However, palpation and percussion is more challenging in the immediate postoperative phase, is observer-dependent and does not afford quantification for repeat comparison. Measurement of intra-

abdominal pressure may allow quantification and comparison over time and can be considered in patients developing abdominal distension after major abdominal surgery or trauma ^{73,74}. Intra-abdominal pressure measurement can assist with identification of abdominal compartment syndrome, a life-threatening consequence of abdominal distension of any aetiology, that requires definitive intervention rather than just increasing organ support within the intensive care unit ^{75,76}. However, interpretation of dynamics of intra-abdominal pressure requires adaption for abdominal compliance and any pressure value must be considered relative to the patient, the surgery completed and other organ dysfunction ^{71,77}.

In the later postoperative course, bowel distension, commonly along with bowel paralysis, is the main cause of abdominal distension. For some institutions that are familiar with intra-abdominal pressure monitoring (Figure 2), repeat intra-abdominal pressure monitoring over time can provide dynamic information and trigger further imaging. Importantly, imaging may only reveal dimensions of the bowel without quantifying the internal pressure applied to the bowel wall. Therefore, radiology findings commonly refer to bowel dilatation, whereas distension is a clinical diagnosis (pressure being commonly associated with discomfort/pain/tenderness) ⁶⁹.

The rationale for abdominal distension as a clinical sign in the critically ill

Gastrointestinal dysmotility is frequently associated with abdominal distension ¹⁴. Clinical examination to differentiate increased volume from pathognomic distension (increased volume and pressure) is challenging in the ICU, particularly in patients receiving sedation, analgesia and muscle relaxant. However, clinically identified abdominal distension is associated with intra-abdominal hypertension ⁶⁵.

Digestion and absorption of carbohydrates and lipids can be impaired in the critically ill ⁷⁸⁻⁸¹. Accordingly, this may result in modest increases in abdominal girth without symptoms – i.e. increase

in volume without additional symptoms, signs or tests that suggest corresponding increase in pressure – that may be initially treated with variation in supply of carbohydrate or lipid to the colon⁸¹⁻⁸³. Fermentation of an endogenous substrate may also be due to slow colonic transit or changes in the microbiome, which may respond to specific intervention to stimulate defecation or increasing the diversity in the microbiome⁸³⁻⁸⁸.

However, an increase in volume with additional symptoms, signs or bedside tests indicative of an increase in pressure – e.g. pain, absence of bowel motions, profuse diarrhoea, tenderness, hyperlactatemia and increased gastric residual volume – should trigger further investigations, monitoring or intervention.

What is known about using abdominal distension as a clinical sign in the critically ill?

In several cohort studies conducted in the critically ill abdominal distension or bowel distension in the critically ill has been included as one a sign of pathology /symptom in several cohort studies^{52,65}.

However, in previous studies abdominal distension was identified either with a subjective clinical assessment, where pressure was also present, or by an enlargement of bowel identified radiologically. Whilst intra-abdominal pressure was measured in many of the patients, intra-abdominal hypertension was included as an additional and separate physical feature. The majority of patients with 3 or more concomitant gastrointestinal symptoms had intra-abdominal hypertension⁶⁴. None of these studies report an association between an isolated physical feature of abdominal or bowel distension and death. However, when distension was incorporated with other features, then the presence of 3 or more gastrointestinal symptoms was independently associated with increased mortality⁶⁴. Accordingly, abdominal distension may provide important information as part of a comprehensive clinical assessment until reliable bedside monitoring tools become available.

ADVICE FOR CLINICIANS AND FUTURE DIRECTIONS

Enteral nutrition remains a component of routine care ^{11,29} and **the authors** recommend against waiting for gastrointestinal sounds prior to starting enteral nutrition. Similarly there are no data to suggest daily cursory auscultation *per se* to decide whether enteral nutrition will be of benefit. However, when auscultation is a component of a more comprehensive assessment of gastrointestinal function, and the presence or absence of gastrointestinal sounds is incorporated with other examination features and simple bedside tests auscultation probably has an additive role.

If an increase in abdominal volume occurs without additional features, clinicians can consider a reduction in carbohydrate load, strategies to increase the diversity of the microbiome or measurement of intra-abdominal pressure. None of these interventions are, however, supported by unequivocal data from randomised clinical trials. Intra-abdominal pressure may be useful when there is uncertainty about the need for additional investigation/s that require transport out of the intensive care unit or an intervention that is associated with more than negligible risk.

Whether decisions based on such complex assessment of a constellation of imprecise symptoms, signs and test results improve outcomes remains untested. However, without a proven alternative, **it is the opinion of the authors that** the use of minimally-invasive and inexpensive assessment methodologies is better than abandoning routine assessment of gastrointestinal function. Because excessively aggressive administration of enteral nutrition may cause harm ³¹, a daily evaluation with early identification of serious events such as non-obstructive bowel ischemia and critical bowel distension with life-threatening perforation should continue as part of routine care.

Given this, the use of technology to allow prolonged periods of minimally invasive observation, with presence and characteristics of gastrointestinal sounds validated using objective criteria, warrants further evaluation. This technology may be particularly useful in cohorts of patients for whom clinicians remain uncertain about whether to initiate or increase enteral nutrition, such as those with

hypotension requiring considerable vasopressor support or profound hypoxia or acidosis ^{11,13,31,32,89}.

Future studies should also produce data that informs when to initiate intra-abdominal pressure monitoring and what interventions are effective once intra-abdominal hypertension is identified.

For Peer Review

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Figure captions:

Figure 1. Bedside assessment of the gastrointestinal tract

Figure 2. Intra-abdominal pressure is measured in the supine, paralysed patient at end-expiration via a transducer in continuity with the bladder, zeroed at the mid-axillary line. 25ml of fluid is instilled in the empty bladder and the pressure taken after 60 seconds.

For Peer Review

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Figure 1. Bedside assessment of the gastrointestinal tract

179x178mm (600 x 600 DPI)

Figure 2. Intra-abdominal pressure is measured in the supine, paralysed patient at end-expiration via a transducer in continuity with the bladder, zeroed at the mid-axillary line. 25ml of fluid is instilled in the empty bladder and the pressure taken after 60 seconds.

174x127mm (600 x 600 DPI)

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Are Classic Bedside Exam Findings Required to Initiate Enteral Nutrition in Critically Ill Patients: Emphasis on Bowel Sounds and Abdominal Distension

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