



Clinical Potpourri

Experiences with capnography in acute care settings: A mixed-methods analysis of clinical staff



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ABSTRACT

Purpose: Although capnography is being incorporated into clinical guidelines, it is not used to its full potential. We investigated reasons for limited implementation of capnography in acute care areas and explored facilitators and barriers to its implementation.

Methods: A purposeful sample of physicians and nurses in emergency departments and intensive care units participated in semistructured interviews. Grounded theory, iterative data analysis, and the constant comparative method were used to analyze the data to inductively generate ideas and build theories.

Results: Nineteen providers were interviewed from 5 hospitals. Six themes were identified: variability in use of capnography among acute care units, availability and accessibility of capnography equipment, the evidence behind capnography use, the impact of capnography on patient care, personal experiences impacting use of capnography, and variable knowledge about capnography. Barriers and facilitators to use were found within each theme.

Conclusions: We observed varied responsiveness to capnography and identified factors that work to foster or discourage its use. These data can guide future implementation strategies. A deliberate strategy to foster utilization, mitigate barriers, and broadly accelerate implementation has the potential to profoundly impact use of capnography in acute care areas with the goal of improving patient care.

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1. Purpose

Capnography, or continuous end-tidal carbon dioxide monitoring, is the graphic representation of carbon dioxide expired during the respiratory cycle. From its inception in the 1960s, evidence has grown to support capnography for a variety of indications and patient populations [1–5]. This has led to its inclusion into national guidelines for recommended use [6–9].

Large gaps exist between evidence and practice. As demonstrated in studies of emergency departments (EDs) and intensive care units (ICUs), capnography is available in these settings but is not used to its full extent [10–14]. Although there are many factors involved in the successful adoption and implementation of new technologies, little research exists to describe how new bedside, patient-care devices are incorporated for routine use in the work environment [15,16]. Physicians, nurses, or hospital administrators can initiate the purchasing phase of a new device. Thereafter, the ways in which medical units implement new technologies are based on repeated behaviors dictated

by policy and customs that characterize these units' daily activity and are often influenced by adult learning practices [16]. As medical technology advances, implementation of new technologies becomes ever more commonplace and these routines often change. It is important to incorporate learning theory and identify variables necessary for technology adoption to be successful. Some barriers to adoption and implementation are based on physician perceptions and local culture. Overall, these processes are not well understood [17].

This is the first study to assess current perceptions about capnography and investigate reasons for limited implementation at the bedside in acute care areas. Our goal was to learn from clinician experiences in acute care settings with capnography and explore the facilitators and barriers to its implementation. Identification of these key issues and their relationship to adult learning theory is required to identify effective implementation strategies for acute care settings.

2. Materials and methods

To better understand medical providers' perceptions, experiences, and beliefs about capnography, a mixed-methods exploratory study was conducted at 5 sites in Connecticut [18,19]. To achieve a broad perspective, sites included Yale-New Haven Hospital, an urban, tertiary care, academic center; Connecticut Children's Medical Center,

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a freestanding, academic children's hospital; Yale-New Haven Children's Hospital, a nonfreestanding, academic children's hospital; Bridgeport Hospital, an urban, private hospital; and Norwalk Hospital, a suburban, community hospital. Using semistructured interviews, we explored health care provider experiences with capnography and obtained insight into facilitators and barriers to its implementation in ICUs and EDs [18,20].

Our interdisciplinary research team consisted of an administrative coordinator with experience in qualitative interviewing (PS), a general pediatrician with expertise in qualitative methods (AGA), 2 pediatric emergency medicine physicians with experience in qualitative research (AR, MLL), and a medical student (JCK). We used purposeful sampling of interviewees in an effort to enroll participants that would have had an opportunity to use capnography at the bedside [18,20,21]. Departmental heads and nurse managers from each unit were contacted by the study investigator (MLL) and asked to identify colleagues who spent the majority of their time in a clinical role. One physician and one nurse from the ED and ICU of each site were targeted for enrollment. Individuals were contacted by telephone or e-mail about study participation and provided a written information sheet. A small monetary incentive was provided at the completion of the interview. Basic demographic information was collected from participants. The institutional review board of each participating hospital approved this study.

Data collection ran from July 2012 through December 2012. Interviews took place within the participants' institution at a time and place convenient to the participant and were all conducted by one investigator (PS). A semistructured interview guide with probes was used, which explored providers' knowledge and opinions about capnography and their experiences with capnography in caring for patients [18,20]. This was part of a larger interview that discussed new technology in general. Participants for whom capnography was available but who did not use capnography were queried about potential reasons for nonuse. The interview guide was piloted with a nurse and physician who have used capnography in the clinical care of patients. The interviews, which lasted an average of 30 minutes, were audiorecorded and professionally transcribed. Missing text from the transcriptions were compared to the original audio recordings and retranscribed for completeness by one investigator (MLL). The interview guide was iteratively adapted after the first several interviews.

2.1. Data analysis

The principles of grounded theory were applied, including iterative data analysis and the constant comparative method, such that the data were used to inductively generate ideas and build theories [18,21,22]. Three investigators read and independently coded each transcript (MLL, AR, JCK). The coding team then met and reviewed each transcript line by line. Discrepancies in coding were discussed until group consensus on the data was established. Related concepts were then combined into categories, and emergent themes were identified consistent with a grounded theory approach to describe key issues and experiences discussed by the participants. participants [18,21,22]. An iterative process of data analysis occurred such that codes were revised, added, and deleted to refine the code structure [18,20–22].

The first and second rounds of analysis focused on questions within the interview guide to allow subsequent interviews to be shaped by the preceding analysis. Changes to the interview guide based on the inductive analysis were explained and recorded to enhance reliability and reproducibility of the study [20,21]. Recruitment and interviews continued until data reached theoretical saturation, that is, until no new themes emerged [18]. Once the code structure was finalized, the primary author (MLL) reviewed all transcripts to ensure that the data were coded consistently. One study investigator (AGA) independently reviewed selected transcripts in

the process of data triangulation [18,20,21]. An audit trail was created to provide systematic and detailed documentation of analytical decision making during this process. HyperResearch (ResearchWare, Inc), a qualitative analysis software tool, was used to organize the analysis of transcribed data. This allowed us to collate data by type of participant, unit, and hospital [20,23].

Cohen's κ was used to assess the agreement in reporting of use between providers from the same unit. Fisher exact test and Student t test were used to analyze demographic data and assess for differences among those reporting capnography use and nonuse.

3. Results

Nineteen acute care providers were interviewed from 10 hospital units. The nursing staff from 1 ED refused to participate. Participant characteristics are summarized in Table 1. There was excellent agreement between respondents (κ , 0.89; 95% confidence interval, 0.68–1.0); that is, physicians and nurses from the same unit expressed similar views about the availability and overall use of capnography in their setting. Three units (2 ICUs and 1 ED) reported that capnography was used rarely or not at all. All remaining units had some degree of capnography use. There was no statistically significant difference in report of use by type of unit ($P = .63$), age of providers ($P = .85$), or number of years for which the provider was working on the unit ($P = .31$).

We identified 6 themes surrounding use of capnography. These include existence of variability in capnography use among acute care units, availability and accessibility of capnography equipment impacts use, dissimilar interpretation of the evidence behind capnography use, disparate views on capnography's ability to impact patient care, experiences with capnography impacting future use, and diversity of knowledge about capnography interpretation. Categories corresponding to barriers and facilitators within these themes are summarized below and presented in Table 2 along with illustrative quotes.

3.1. Variability exists in capnography use among acute care units

Capnography use varied among ED and ICU staff. Most participants reported use for selected patient populations and indications as well as lack of use for others. More importantly, there was variable use among staff members within a unit. On some units, staff champions promoted the use of capnography for certain indications; but it was perceived that capnography was not used as often when these individuals were not present. This is in contrast to other units where policies are in place to standardize use by staff. Overall, cultural and administrative issues within the units were reported that influenced providers' patterns of use.

3.2. Availability and accessibility of capnography equipment impact use

The ability for providers to quickly access capnography is a key factor that providers identified as a facilitator of use in acute care areas. Intensive care units with better accessibility reported more routine use. For instance, ICUs in which responsibility for storage and setup of capnography is largely placed on respiratory therapists

Table 1
Characteristics of study participants

Unit and provider type, n (%)	
ED	9 (47)
Physician	5 (26)
Nurse	4 (21)
ICU	10 (53)
Physician	5 (26)
Nurse	5 (26)
Age (y), mean (min, max)	43 (27, 62)
Years working on unit, mean (min, max)	9.5 (1, 40)

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