Adaptation and innovation: a grounded theory study of procedural variation in the academic surgical workplace

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Abstract

Rationale, aims and objectives—Surgical research struggles to describe the relationship between procedural variations in daily practice and traditional conceptualizations of evidence. The problem has resisted simple solutions, in part, because we lack a solid understanding of how surgeons conceptualize and interact around variation, adaptation, innovation, and evidence in daily practice. This grounded theory study aims to describe the social processes that influence how procedural variation is conceptualized in the surgical workplace.

Method—Using the constructivist grounded theory methodology, semi-structured interviews with surgeons ($n = 19$) from four North American academic centres were collected and analysed. Purposive sampling targeted surgeons with experiential knowledge of the role of variations in the workplace. Theoretical sampling was conducted until a theoretical framework representing key processes was conceptually saturated.

Results—Surgical procedural variation was influenced by three key processes. Seeking improvement was shaped by having unsolved procedural problems, adapting in the moment, and pursuing personal opportunities. Orienting self and others to variations consisted of sharing stories of variations with others, taking stock of how a variation promoted personal interests, and placing trust in peers. Acting under cultural and material conditions was characterized by being wary, positioning personal image, showing the logic of a variation, and making use of academic resources to do so. Our findings include social processes that influence how adaptations are incubated in surgical practice and mature into innovations.

Conclusions—This study offers a language for conceptualizing the sociocultural influences on procedural variations in surgery. Interventions to change how surgeons interact with variations on a day-to-day basis should consider these social processes in their design.

Keywords

evidence-based surgery; grounded theory; innovation; practice variation; procedural variation; surgery

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Introduction

Surgical research struggles to account for the relationship between procedural variations in daily practice and traditional conceptualizations of evidence [1]. Recently published frameworks provide some guidance for understanding the issue and suggest a basis for interventions to address it [2–6]. The problem has resisted simple solutions, in part, because we lack a solid understanding of the sociocultural influences on variation, adaptation, innovation, and evidence in the surgical workplace. The creation of robust theory in this area may assist the development of interventions designed to alter how surgeons interact with each other around variations and evidence in daily practice.

Many of the unavoidable contingencies of surgical practice that factor into the complex relationship between variations and evidence are well explored [7–10]. Surgeons leapfrogged from a handful of interventions on weakly anaesthetized patients in the 19th century to the proliferation of thousands of surgical procedures in the next [11]. Research by Glover in 1938 and Wennberg in 1970s showed that small-area variation – differences in procedure choice from place to place – became widespread over the course of 20th-century surgical practice [12]. The yet-unrealized call for an ‘FDA for surgeons’ in 1975 [13], and the rise of evidence-based medicine in the 1990s [8,14], drew attention to debates about the comparative effectiveness of surgical procedures that had been ongoing for decades [15]. Today, the complexities of surgical practice that make it difficult to identify the most effective variation of a surgical procedure have become a key concern in surgical research [9,16–18]. Producing the now-expected high-level evidence of the comparative effectiveness of interventions has proven more difficult for surgery than other disciplines for many reasons, some of them contingent and unavoidable [2–4]. Clinical equipoise may be harder to maintain in surgical research [19,20]. There is uncertainty about the translatability of descriptions of procedures from literature to practice [21], and the comparability of the same procedure performed by different surgeons is suspect [22]. Recognizing such contingencies is critical [5,23], but it is merely a first step. To move the field forward we must develop a holistic understanding of the factors that influence how surgeons negotiate variations in the social complexities of the workplace.

Surgical research has traditionally assumed that the solution to procedural variation is the implementation of practice standardization interventions. The publication of practice guidelines and consensus statements has indeed been shown to change practices in the workplace [24–26]. But these appear to be incomplete solutions: reversion to the mean is common in medicine generally [27], and it may be especially prevalent in surgery [26,28].

Complex factors such as ‘clinical context’ [26, p. 625] and surgical culture that were once assumed to be irrelevant to how surgeons judge the value of one variation over another are now suspected of playing a more significant role [7]. This sociocultural influence on variations in the workplace has been inadequately addressed in the literature: how surgeons interpret variations they hear about or perform and what they do about them on a day-to-day basis has been left theoretically underdeveloped. Linguistic analyses [29], grounded theory-based content analysis [30] and other forms of qualitative research [28] have attempted to describe how surgeons speak about and define variations in naturalistic settings. But a thorough understanding of the social processes that shape how surgeons interpret and enact variations in their daily lives does not yet exist.

While many interventions have been created to address the problem of procedural variation [26], none fully attends to the role of sociocultural complexities in the surgical workplace. Naturalistic research exploring how surgeons think about and act on variations can produce insights that transcend previous ‘simplistic narratives’ [1, p. 628] regarding procedural variation and can be used to improve the design of such interventions. In this study, we set out to ask how surgeons conceive of variations in surgery, how they decide whether or not to adopt variations, and how their relationship to procedural variations is influenced by their interactions with others in the workplace.

Methods

This three-phase grounded theory [31] study took place over a period of 20 months beginning in January 2013. Our grounded theory methodological approach was primarily rooted in constructivist grounded theory [32] and situational analysis [33]. The goal of grounded theory research is to develop theoretical representations of a social process rather than a deductive theory based on hypothesis and experimentation [34]. This focus makes grounded theory an appropriate methodology for providing fresh perspectives on intractable problems [35].

Sampling in all three phases of the study was guided by the logic of theoretical sampling where the data are collected to inform the evolving theoretical framework [32]. The first stages of the theoretical sampling – exploration and purposive sampling, respectively – were used to develop a research question and to select rich informants [36]. Sample size in grounded theory research is not determined by effect size calculations [34,37] or concerns about generalizability [32,33]; instead, data collection is complete when saturation of the theoretical framework is achieved [32]. In this study, saturation was achieved when no further elements were added to the situational map during the end stages of theoretical sampling [33].

The final data set consisted of 19 interviews with a mean duration of 41 minutes. We restricted sampling to surgeons at academic centres for two reasons. First, as compared with community surgeons, academic surgeons are the group one might most expect to be rich informants about innovating in surgery given their access to the most complex patient cases and the newest technologies. Second, the perceptions of the next generation of innovators –

surgical residents – will be shaped in important ways by their exposure to social processes surrounding innovation in academic training centres.

Interviews were transcribed and coded with assistance from NVivo 10 (QSR International, Melbourne, Australia) data management software. The study was approved by the Research Ethics Board of the University of Western Ontario.

Phase 1: exploration

The initial stage of the study consisted of convenience sampling with key informant surgeons. These consultations consisted of two interviews as well as sixteen hours of observation in the operating room across six cases performed by three key informant surgeons with previous connections to our research centre. Using reflective memos from these interviews and observations [32], we refined our research questions and developed a guide for subsequent semi-structured interviews to explore these questions.

Phase 2: purposive sampling

The purposive sample consisted of surgeons identified by leaders in a single institutional setting as being particularly innovative ($n = 7$). These interviews were conducted using the semi-structured guide developed in the previous stage. The first four transcripts of the purposive sample of interviews were coded using an open, line-by-line coding technique [31,32]. The line-by-line codes were then raised into tentative categories by comparing codes with one another to create a focused coding framework [32]. Throughout this process, analytic progress was continuously tracked using reflective memos [32].

Phase 3: final theoretical sampling

Gaps in the focused code-based preliminary theoretical framework were identified using a grounded theory technique called situational mapping with relational analysis [33] that compares categories to categories to analyse how categories and their subcategories are related to one another. Theoretical sampling and coding was conducted to explore the gaps in the emerging theory. The final-stage theoretical sample ($n = 10$) consisted of surgeons selected to address questions about gaps in the framework, new concepts arising from the memoing process, or cases that presented as discrepant to the framework in the data collection process. The theoretical sample included female surgeons, surgeons in the first 3 years of practice, surgeons working in different academic centres, surgeons self-identifying as mid- to late-adopters of surgical innovations, and further sampling of known innovators. The theoretical framework was refined during this theoretical sampling process. Data collection ended after saturation of the framework was reached [33].

Results

The surgeons in our sample reported that their decisions about disclosing and refining procedural variations depended on social interactions. The findings of this study describe this social process of surgical practice variation. The overarching process was composed of three categories: seeking improvement, orienting self and others to variations, and acting under cultural and material conditions. The categories and subcategories of the social

process are described in full below. The categories have been represented here by synthesizing data from the coded subcategories. Extended representative quotes from each category are included in Table 1. The delineation of categories in constructivist grounded theory research should be considered holistically: while each social process is distinct, one is not necessarily exclusive of the others.

Seeking improvement

Surgeons engaged in practice variation because they experienced *unsolved procedural problems*, they were *adapting to get the job done*, and they were *pursuing opportunities*.

Having unsolved problems was an important instigator of seeking improvement. Every sampled specialty appeared to have a few ‘really difficult problems that we don’t have a solution for’_(S12). These could be cases where adverse outcomes were rare as ‘1 per 1000’_(S04) but when they do occur they’re ‘catastrophic events ... [that can be] a kick in the stomach’ for the surgeon_(S04). They could be cases with ‘patients who were abandoned’_(S09) by the progress of surgical techniques and technologies and thus for whom there is no intervention. Or they can simply be cases where ‘our solutions are just okay ... so any kind of contribution ... can maybe make it a little less challenging’_(S08). Under such circumstances, some participants felt driven to seek out improved practices from colleagues or to investigate the potential of their own variations to solve the problem.

Variations emerged from the day-to-day process of *adapting to get the job done*. Enacting surgical expertise was described as coming to ‘realize that it’s not always in the book’_(S05) and that it is about ‘making individualized decisions in the heat of the moment’_(S15). Solving the problems of daily practice appeared to foster ‘improvisation’_(S06) and ‘ingenuity’_(S01) and to elicit ‘little trick[s] of the trade’_(S03). While it was suggested that, for these adaptations, ‘there’s probably not the evidence to support it being in the textbook’_(S03), they can sometimes be improvements that make ‘it simpler technically ... [and have] less complication risk’_(S07). In some cases, if the ‘community recognizes ... [it] as a challenging problem’_(S08) then it ‘may lead to the adaptation sticking ... [because] if the adaptation worked for some, you know, then it will work for others’_(S09). Our participants described actively remembering these adaptive variations for later personal use or as potential innovations to be shared with others.

The process of *pursuing an opportunity* to explore a variation could follow from an adaptive variation or from more strategic concerns. ‘External pressures’_(S16) from hospital administration, clinical departments, or patients themselves also prompted surgeons to pursue investigating variations that were new to them. Other times, an interesting variation could be suggested by a colleague or resident, or an ‘industry person [could bring a] technology’_(S07) forward to the surgeon to try. In these cases, the variations in practice could appear to the surgeon considering them to be opportunities to put ‘things in the literature that are of value to surgeons and would be of value to patients’_(S05). Pursuing these types of opportunities made a significant difference to surgeons who aspired to secure an academic position and feel called to ‘stand up and do something different and be different ... [to get] a good job’_(S13). Pursuing variations was thus not limited to adaptive variations felt to fill procedural gaps but was influenced by personal, professional, and institutional goals.

Orienting self and others to variations

This second category in the framework involves *taking stock* of a variation, *sharing stories* of variations with others, and *placing trust* in the variations perceived in the course of practice and socialization.

Deciding how to move forward with a variation elicited a process for the participants in our sample of *taking stock* of how the variation might promote various interests. Considerations about the variation included ‘how easy it’s going to be to reproduce’^(S09); whether or not the variation could make ‘a quality of life impact’^(S10); whether the variation was ‘kosher ... [or it] broke these principles of surgery’^(S01) and thus would be riskier to promote; or whether it could ‘generate the publications you need to keep going’^(S15). The personal costs of getting ‘a trial going, which in our day and age would need to be multicentred, which is very skill-specific and resource-specific kind of study to undertake’^(S10) were also taken into account. The perceived benefit was weighed against these logistical complexities of surgical research ‘which usually means you have to recruit surgeons to participate in the study and be willing to either be randomized or [adopt] new ways of doing things’^(S17) which can become ‘a big barrier ... to mak[ing] it worthwhile’^(S17). Local conditions such as the ‘deliverables and expectations provided to [the surgeon]’^(S02) when he or she is hired shaped how the surgeon perceived the value of pursuing further exploration of the variation. The perceived value of a variation depended on characteristics such as its reputational riskiness, its logistics for further exploration, and its place in the surgeon’s career trajectory rather than on its perceived utility alone. Further, these logistics and contingencies were subject to change; therefore, participants described continually revisiting taking stock as new information became available and their social environment evolved.

Sharing stories was a way of gauging the reactions of colleagues to variations. The process of sharing stories could occur during the natural flow of work when a second surgeon is called in to assist, a different surgical service is consulted, or new members of the surgical team come aboard. As one participant stated, stories are shared inside the operating room: new trainees, especially fellows, can be a ‘way for me to learn about how the other surgeons do certain things, techniques, or some tricks and whatnot’^(S11). Sharing stories of variations outside of the operating room also seemed to be ‘a regular source of conversation ... [where one can] acknowledge that there are different ways of doing things’^(S10). According to one surgeon in our sample, ‘even in this immediate transmission, electronic era, that’s the main way by which innovative knowledge is passed along, by the old traditional caveman methodology, storytelling ... [and] there’s informal storytelling and formal storytelling’^(S09). Formal storytelling about variations was acknowledged as an important part of discussing and disseminating them, yet, especially across our purposive sample, the importance of informal storytelling was highly emphasized: ‘It’s very rare to learn anything new when you sit there and listen to talks [at conferences]. What you learn more is just communicating with people, during the day, one-on-one’^(S03). The process of sharing informal stories about variations during ‘hallway conversations [and] being in clinic together’^(S08) and ‘coffee breaks at [specialty] meetings ... [and] when we’re not examining’^(S09) at licensing examination were reported as both rich sources of learning and important testing ground for variations under consideration.

The process of *placing trust* in the stories and variations of others was present in the entire sample and particularly pervasive among the known innovators in our purposive sample. Placing trust refers to the act of using the thoughts and opinions of others to gauge the value of variations. The surgeons in our sample built relationships around procedural variation and reported making clinical decisions using that information. It was suggested that ‘the surgical model of training is still very much an apprenticeship-based model where you have a master and an apprentice’ (S15). In this model, the ‘principles ... the outlined dogma of surgery ... you learn those in residency’ (S14). Principles were understood to be ideas ‘passed down from generation to generation over centuries of things that you’re supposed to do to have a good outcome’ (S01). It was suggested that a surgeon can ‘coach residents to make a distinction between a preference and a true, true principle ... [but] the more common the operation, the more diverse the techniques become’ (S12). Deciding whose of these variations or opinions to trust could depend on ‘reputation’ (S01), ‘credibility’ (S17), authority or positions of ‘leadership’ (S10), a ‘supportive atmosphere’ (S09), ‘seeing someone who is really technically expert’ (S12), or, most commonly, on having a relationship upon which participants can rely on for ‘support [for their] ideas and intuitions’ (S13). While the process of placing trust was ubiquitous across the sample, the surgeons in the purposive sample especially discussed seeking out a faculty ‘mentor and friend’ (S08) who would be open-minded, ‘where there is no real [procedural] rights or wrongs’ (S06) whom they could ‘bounce things off’ (S08). When considering investing the time and resources into investigating a variation, innovators in the purposive sample felt that the genesis of research depended on finding a mentor where ‘if something goes bad [while doing a variation, the mentor] is going to be stepping up’ (S13) and protecting the innovator’s reputation. Proceeding to explore that variation was reported to require a relationship of mutual trust with a mentor ‘whose opinion you can look to when the evidence and the research is ambiguous’ (S13) or who can efficiently give orienting information on a variation such as ‘yeah, I tried that in 1971 and it didn’t work’ (S09).

Acting under cultural and material conditions

The process of acting under cultural and material conditions regarding practice variation depended on *positioning image*, *being wary*, *showing the logic* of the variation, and *making use of academic resources* to do so.

Positioning image involves negotiating variations and who uses them at what time. In ‘surgery, traditionally ... image management reigns supreme’ (S09). As one participant stated, ‘I know a couple surgeons who, whatever one says, the other won’t do and vice versa, even if it makes sense ... That’s not so much the technical credibility part as it is the underlying social, cultural environment that goes around this issue’ (S17). Participants describe assessing variations – the risk profile, the potential value – and making decisions about the use of those variations based on the kind of image he or she is working to cultivate. Establishing a solid reputation based in collaboration and open communication around variations is a potential consequence of ‘team-based management where patient outcomes rather than surgeon autonomy is the new paradigm’ (S09). As one participant tells it: ‘I don’t have to clear [a variation] by anybody. But, at the same time, I would want to avoid my colleagues looking at what I’m doing and saying “why is he doing this?” ... [so] I would probably run it by them in an informal way’ (S15). The result is a social process around variations where,

‘instead of being the cowboy, instead of being the lone ranger or the bullfighter ... I [speak] with people and [say] OK ... we’re going to do this’_(S13).

Surgeons also approached procedural variations and decisions about their use with suspicion. Participants described *being wary* of both innovations and current best practices: ‘The evidence, the actual scientific evidence, for any kind of innovation, usually lags a long time between the idea and it coming up ... [W]ith each incremental change, you’ve had to say, “OK, I have to give up what I thought I knew, and re-evaluate this whole new thing” ... It leads you to begin to say, “do we ever really know anything?”’_(S12). This wariness shaped how interactions around variations took place. Our participants suggested that those who fail to understand being wary as a cultural norm may be less likely to be trusted by their peers. It may not be culturally appropriate to say to a peer, ‘I can’t believe you did it this way’_(S15); rather, it may be more appropriate to wait until asked and say, ‘why don’t you try this, it worked for me once’_(S17). These norms for informal conversation were also found in the formal storytelling and research context. Participants suggested that being wary of behaviours that prioritized the presenting surgeon instead of the research on the variation itself is part of being a good critical assessor. In these cases, if ‘they’ve got kind of a slick style ... [it raises] a question of trusting what they’re saying ... and that they’re not sort of trying to build their reputation and maybe inflating their results or minimizing complications’_(S08). This kind of wariness was pervasive in participants’ descriptions of both informal and formal storytelling.

Participants perceived *showing the logic* to be a component of abiding by cultural and material conditions during the process of sharing stories. From teaching in the operating room to publishing in peer-reviewed journals, time and other resources were invested in showing *why* a variation works. On the teaching side, ‘you’ll say something like, “I’m sure you will have been taught a number of different ways” ... or “I know there’s controversy around it but ... I’m most comfortable with this approach.” Then very often you’ll finish the statement with something like “because X, Y, and Z”’_(S10) or ‘this is a deviation from what you will have read in the textbook, but here’s the justification for it’_(S07). On the research side, this cultural expectation pushes surgeons away from publishing case studies or descriptions of using a variation, as ‘for most of us, we would describe that as being low-level research because that’s a look-at-me, look-what-I-did kind of thing’_(S01). Instead of publishing a ‘one-off’_(S16), it was perceived as a simple matter of ‘interest and a matter of devoting the time’_(S06) to collect the culturally appropriate data. Surgeons reported that these cultural and material conditions may ‘detract from a lot of interesting innovations coming to fruition from the community’_(S06), but that academic surgeons feel it is ‘expected to do those things’_(S06), to investigate the discrete steps and biophysiological mechanisms that underlie proposed variations. As one participant in our sample told it, ‘[w]e came up with the [X] technique ... [but] we didn’t actually go into the steps right away’_(S04). What had to come first, he explained, was a years-long process of collaborative research on the steps and biophysiological mechanisms that guide them.

Making use of resources in academic centres was a consequence of perceiving an imperative to show the logic. Residents and other learners act as vectors of information about variations in academic centres. Surgeons can ‘learn some of [their] colleagues’ tricks through the

fellow' (S16) or resident, and programs of research can be 'provoked by a resident or fellow saying "I've not seen that before"' (S08). Learners also provide a source of labor in building complex programs of research 'to do some scut work, like do the statistics, to do the measurements' (S04). The process of showing the logic, or showing *why* a variation works, can rely on these human resources specific to academic centres: '[W]e know it happens, but we don't know why ... So then one of our residents who is very involved in basic sciences is taking biopsies of these and taking them to the lab, understanding, moving forward' (S13).

Discussion

The history of surgery is one of continuous innovations [11,19]. The current milieu demands evidence to support the adoption of innovations [17,27]. However, what constitutes an innovation and how innovations become accepted as evidence is an incompletely understood process in part because its social and cultural dimensions have not been well explored [38,39]. The findings of this study confirm that what counts as evidence and how surgeons use it on a day-to-day basis is shaped by complex social processes and cultural expectations around procedural variations [23,40]. Developing a new understanding about what evidence is, and how it is used, productively reframes current debates about evidence in surgical practice. Such reframing may help improve interventions that attempt to address surgery's perceived gap between evidence and practice by attending to the social processes and cultural expectations of procedural variation.

Procedural variation is common among surgeons [1,7,17]. Some surgical research has suggested that surgery's lower rate of use of traditionally expected sources of evidence [8,9] such as randomized controlled trials is caused by a lack of, and poor understanding of, high-quality published evidence [5]. However, the findings of this study show that surgical procedural variation is not solely caused by such deficits. The surgeons in our sample were not simply translating the newest research or guidelines into their procedural approaches in an uncomplicated fashion. Our participants, largely innovative surgeons in academic centres, were not making ground-breaking changes in individual moments of genius nor were they incrementally adjusting procedures only as far as the rigorously collected evidence told them was safe, as suggested in previous research [11,20]. Instead, they were motivated to adapt procedurally by everyday circumstances, and they exhibited a selectivity around disclosing and producing evidence for those adaptations that was based on specific social processes.

This study examined surgeons' reports of their everyday practices and found that they engaged in a continuous, small-scale process of seeking improvement. They reacted to perceived procedural necessity by adapting rather than only creating new procedural variations *de novo*. Adaptations were selectively shared with and taken up by other surgeons after a period of incubation shaped by complex social processes. The process of orienting self and others to variations required established social relationships through which to interpret and represent information about procedural variations. When they did decide to disclose their variations, and pursue maturing an adaptation into an innovation, cultural and material conditions shaped the form and content of their stories. We found that the evidence used by surgeons to make decisions around variations is both interpreted and produced based

on from whom the variation derives and how it does or does not fit into their professional plans.

This complex relationship between everyday variation and evidence was evident in how our participants blurred the boundaries between the meanings of the terms ‘variation’, ‘adaptation’, and ‘innovation’. Following precedents in the literature, we have used ‘adaptations’ to refer day-to-day procedural variations [19,41,42] and ‘innovations’ to refer to procedural variations that are researched and disseminated to other surgeons [11,30,43]. Previous research on surgical variation suggested that ‘at some point these adaptations become “innovation”’ [20, p. 216] [19]. Yet current surgical research claims that surgeons conceptually distinguish between innocuous day-to-day adaptations and major research-based innovations [30,44]. The findings of this study indicate that day-to-day adaptation and innovation are different categories of the same concept in surgical practice. In our sample, they are primarily distinguished from one another by the social processes involved in choosing an adaptation to turn into a program of research rather than by being immediately identifiable as a minor adaptation or a major innovation from the moment a variation comes to light. That all three major categories included strategic social processes which previous research suggests are explicitly disavowed in surgical culture [23] supports this finding. Social processes of a highly strategic nature such as *pursuing opportunities*, *taking stock* and *positioning image* orient surgeons to make decisions about potentially important variations based on personal and contextual factors rather than on efficacy and utility alone. The strategic commonality between these social processes transcends the major categories and suggests that understanding how variations move from incubation into maturity requires understanding of how surgeons tacitly endorse and make use of disavowed concepts [23].

The findings of this study confirm previous suggestions that surgeons’ processes of sharing of information about procedural variations are socioculturally shaped. Yet, suggested interventions in surgery’s pursuit of higher level evidence do not incorporate social processes into their design. The Balliol Collaboration’s IDEAL framework [7,16,45,46] – Idea, Development, Exploration, Assessment, and Long-term study – is one suggested approach to resolving the ‘difficult[y] [of] transform[ing] surgical culture into an evidence-seeking profession’ [7, p. 9]. The ‘Ideas Database’ component is the first step of the framework, and it is the one to which our data are most relevant. It primarily consists of a yet-to-emerge online database or repository for tracking surgeons’ day-to-day procedural adaptations to facilitate research on such variations [4].

Understanding how such a database might be used in the production of evidence has proven difficult. The Collaboration has grappled with concerns about anonymity [4] and alluded to the role that unknown social complexities may play in how evidence in surgery is perceived and used [16]. The findings of this study suggest that there are highly specific social processes and cultural expectations at play that have implications for how, and whether, the material existence of a database of variations would advance efforts to produce surgical evidence. Achieving its intended goals of capturing day-to-day adaptations and fostering research on such variations would rely on surgeons engaging with the Ideas Database and using it as a storehouse for procedural variations. This study suggests that surgical culture is built around stories of variations that take on specific forms shaped by direct social

interaction. On one hand, an underlying *wariness* in surgical culture appears to necessitate lengthy and resource-intensive process of *showing the logic* of variations and an aversion to making one-off adaptations public knowledge. On the other hand, especially in our purposive sample of innovating surgeons, the social process of *placing trust* in a colleague who can listen and speak supportively about variations was a determining factor in moving a variation from incubation to maturation. It is unlikely that surgeons will either deposit meaningful descriptions of variations on an anonymous database or perform research on the variations they find there without mechanisms for attending to these relationship-building needs absent of anonymity.

There are some limitations to consider in our study. Current research shows that the process of negotiating variations in academic centres may have some unique characteristics, especially for learners [47,48]. While this study was conducted only in the academic setting, thorough understanding of the social process of practice variation will require investigating differences between how variations are negotiated in both academic and community settings. The value placed on publication in academia and academic surgeons' focus on the maturation of variations may be characteristic of the reward systems in academic practice. Further research might investigate, for instance, how adaptations in community settings mature into innovations or if such maturation is dependent on the availability of venues for sharing stories between surgeons. The implications of the practice variation process for surgical education itself were not directly explored because this study focused on surgeons alone. The findings of this study indicate that a thorough exploration of the role of procedural variation in surgical education will require theory that is attuned to the complexity of the procedural variation process. Socio-material theories of learning that work to sensitize researchers to the entangled relationships between social processes like positioning image, materials like surgical tools, and discourses like procedural guidelines will play a key role in developing this new theoretical domain in the future [49,50].

Conclusions

Complex social process and cultural expectations influence the way procedural variations are understood in surgical practice beyond traditional considerations of efficacy and utility. Understanding how such factors shape the interpretation of variations can improve the design of interventions intended to alter the way surgeons navigate variations and evidence in the workplace. Future clinical research should consider such social and cultural factors when attempting to implement changes in surgical practice. These findings suggest that further research on the practical and theoretical implications for learning in the surgical context will be required to fully understand how these social processes are enacted and cultural expectations are adopted.

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Table 1

The surgical practice variation social process framework

Seeking improvement	Having unsolved problems	'When it happens it's a catastrophic event because ... you have significantly more bleeding and mortality in the patients ... You say "why did this happen, why did it happen to me, and what have I done wrong here?" You always try to blame yourself, you say "did I do something wrong or did something happen due to an accident?" ...[So] I wanted to see what are the reasons and see if we can solve the problem'. (S04)
	Adapting to get the job done	'As you do become a surgeon, you'll realize that it's not always in the book ... [It] is a bit like carpentry, you have to move forward somehow. How did I come up with that [variation]? I don't really know. I presume it's a result of many years of being in situations where you couldn't follow the plan, and I'm trying to innovate during real time ... Every surgeon does ...' (S05)
	Pursuing an opportunity	'I was stuck with a procedure that's usually done open, and I'm trying to do it only [minimally invasively] at the lowest cost possible because the hospital budget is cutting down on endowments so we're stuck ... I was debating certain technical points so I went to the office just next door to mine. I asked my colleague "hey, have you done this? Do you think I could try this tool?" ... He said "oh yeah, there's a video there that I've seen before." He went to Google, found a video, and he said "maybe you could try this place, this [tool], and whatnot".' (S11)
Orienting self and others to variations	Taking stock	'I think now this culture has evolved where people ... need to know up front what it is that is expected of them and the kind of research that they need to be involved in. For some of them it's not research but it is going to be an educational piece or educational research and maybe not clinical trials or lab-based research'. (S07)
	Sharing stories	'When the outcome [of a variation] is good, you then often reflect on that and say, "well, that's pretty cool." And, sometimes you want to share that with your colleagues and other people and say "look what I did, wasn't that crazy, but man, I got away with it and look at how good it was." And then it becomes something that maybe you keep in your little toolbox of, "if I ever get in a situation like that again I might do this, or maybe I'll adapt this for that situation".' (S01)
	Placing trust	'Hearing a presentation from somebody that I trust and respect, and recognising that that's probably going to be potentially a better result than what I'm getting now ... [Procedural change is about] relationships you've developed over the course of your residency and/or fellowship that you either know people directly or kind of secondarily and you've come to recognize that what they say is probably the result. They're being truthful about their results. They're honest about complications. And that's a big part of it'. (S08)
Acting under cultural and material conditions	Positioning image	'I think the decisions I made in the first couple of years may have been less risky, because I wanted to make sure I established myself as a safe surgeon with good judgment. I feel like I have that reputation now so maybe I'm willing to step out and take a few more risks. And I've seen some colleagues, as they get near the end of their career, take less risk. I almost wonder if there's an arc to this, where you start out not wanting to be an outlier and then as you move along being more comfortable with being an outlier and then, near the end of your career maybe wanting to make sure that you don't leave everyone's remembrance of you as a sour question'. (S01)
	Being wary	'I've trained with a lot of surgeons, as well, where you cannot say I saw this with Dr. Whatever and this is what we did or, I saw something else similar in another rotation and this is what we did ... You would never tell somebody "Dr. So-and-so does it this way, have you thought about that?" unless they ask you. I think it's politeness. I think most people are polite in that way that they won't divulge that information'. (S06)
	Showing the logic	'What I was taught, again, it's not in the textbooks but there's a nice little trick that you might need to do and what I will sometimes bring up to the residents, is that you flip it around and do it backwards so it sits better. But you have to say, this is a deviation from what you ... will have read in the textbook, but here's the justification for it'. (S07)
	Making use of academic resources	'We have the [learners] kind of as our extension ... They present our work, when people ask them questions, they're essentially questioning us, technically. And then you can take some of those questions and say, okay, you can improve a lot of the stuff we do and it makes you see a lot of things in a new light, because you're always used to looking at things in a certain direction'. (S06)