

# Complementing Operating Room Teaching With Video-Based Coaching

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**IMPORTANCE** Surgical expertise demands technical and nontechnical skills. Traditionally, surgical trainees acquired these skills in the operating room; however, operative time for residents has decreased with duty hour restrictions. As in other professions, video analysis may help maximize the learning experience.

**OBJECTIVE** To develop and evaluate a postoperative video-based coaching intervention for residents.

**DESIGN, SETTING, AND PARTICIPANTS** In this mixed methods analysis, 10 senior (postgraduate year 4 and 5) residents were videorecorded operating with an attending surgeon at an academic tertiary care hospital. Each video formed the basis of a 1-hour one-on-one coaching session conducted by the operative attending; although a coaching framework was provided, participants determined the specific content collaboratively. Teaching points were identified in the operating room and the video-based coaching sessions; iterative inductive coding, followed by thematic analysis, was performed.

**MAIN OUTCOMES AND MEASURES** Teaching points made in the operating room were compared with those in the video-based coaching sessions with respect to initiator, content, and teaching technique, adjusting for time.

**RESULTS** Among 10 cases, surgeons made more teaching points per unit time (63.0 vs 102.7 per hour) while coaching. Teaching in the video-based coaching sessions was more resident centered; attendings were more inquisitive about residents' learning needs (3.30 vs 0.28,  $P = .04$ ), and residents took more initiative to direct their education (27% [198 of 729 teaching points] vs 17% [331 of 1977 teaching points],  $P < .001$ ). Surgeons also more frequently validated residents' experiences (8.40 vs 1.81,  $P < .01$ ), and they tended to ask more questions to promote critical thinking (9.30 vs 3.32,  $P = .07$ ) and set more learning goals (2.90 vs 0.28,  $P = .11$ ). More complex topics, including intraoperative decision making (mean, 9.70 vs 2.77 instances per hour,  $P = .03$ ) and failure to progress (mean, 1.20 vs 0.13 instances per hour,  $P = .04$ ) were addressed, and they were more thoroughly developed and explored. Excerpts of dialogue are presented to illustrate these findings.

**CONCLUSIONS AND RELEVANCE** Video-based coaching is a novel and feasible modality for supplementing intraoperative learning. Objective evaluation demonstrates that video-based coaching may be particularly useful for teaching higher-level concepts, such as decision making, and for individualizing instruction and feedback to each resident.

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Acquiring expertise in a complex skill, such as operating, requires “deliberate practice” (ie, the facilitation of specific task improvement through immediate feedback, problem solving, and performance refinement).<sup>1</sup> Traditionally, surgical trainees acquired deliberate practice in the operating room (OR), with graduated independence throughout training. However, as resident operative experience becomes increasingly limited<sup>2-4</sup> by duty hour restrictions,<sup>5,6</sup> the implementation of fellowships,<sup>7,8</sup> and productivity, quality, and safety pressures on attendings,<sup>3,9-11</sup> concerns about the competence of new graduates have arisen.<sup>9-13</sup>

While surgical training programs supplement their curricula with lectures, web-based learning, and simulation, nothing yet approximates the rich experience of operating. Many efforts neglect adult learning theory principles; they are teacher driven rather than learner driven, didactic rather than interactive, and amassed rather than distributed over time.<sup>14</sup> Few evidence-based methods exist to help trainees evaluate or improve their operative performance.

In other professions requiring accelerated skill acquisition, coaches provide learners with perspective and immediate, targeted feedback.<sup>1</sup> Athletes routinely review performance videos with coaches, who guide them through an individualized self-improvement process. With such directed feedback, deliberate practice is achieved, accelerating the learning curve. Our group previously piloted a video-based coaching intervention for practicing surgeons, demonstrating feasibility, acceptability, and a high perception of value.<sup>15</sup> Qualitative analysis of this continuing professional development module revealed a natural predominance of critical thinking topics, an aspect we suspect is underemphasized in intraoperative teaching. We sought to expand the scope of investigation to residents, hypothesizing that video-based coaching would fill these gaps in their operative education.

## Methods

### Participant Recruitment and Data Collection

We recruited postgraduate year 4 and 5 general surgery residents (to maximize the chance of capturing complex discussions) and attending surgeons at Brigham and Women's Hospital, an academic tertiary care center. A convenience sample of 10 residents was offered a choice of coaches from colorectal, minimally invasive, oncologic, acute care, and transplant surgery.

We videorecorded and audiorecorded 1 operation for each resident-coach dyad (Table 1). Videos captured the surgical field and entire OR, as previously described.<sup>16</sup> Each video formed the basis of a 1-hour one-on-one coaching session conducted by the operative attending, scheduled 0 to 43 days after surgery (mean of 13.6 and median of 5.5 days elapsed). To prepare, coaches were given a “Coaching Residents” pamphlet, adapted from handbooks on coaching or giving feedback in other settings.<sup>17-19</sup> The content of the video-based coaching sessions was determined entirely by the participants; we neither mandated nor suggested discussion topics. The video-based coaching sessions were audiorecorded. Written informed con-

### Key Points

**Question** Is post hoc video-based coaching an effective modality for teaching residents to operate?

**Findings** This mixed methods analysis compared teaching in a video-based coaching session with teaching during the corresponding operating room case. During video-based coaching, instruction was more individualized to the resident, and higher-level concepts, such as decision making, were discussed.

**Meaning** In this era of reduced resident operative time and autonomy, intraoperative education may be supplemented by video-based coaching.

sent was obtained from surgeons and patients. The study was approved by the Partners Institutional Review Board.

### Coding

Operating room videorecordings<sup>20</sup> and coaching audiorecordings were transcribed with patient and surgeon identifiers removed. A preliminary coding schema was adapted from prior surgical education work<sup>15,21-23</sup> and then refined through an iterative inductive coding process. Two surgical research fellows (Y.-Y.H. and L.M.M.) independently reviewed each transcript to identify teaching points, coding them by initiator, content, teaching technique, and tone. When the initiator was the resident, the attending response was coded as open, closed, or reflective. Two deidentified transcripts of OR videos from a prior study<sup>24</sup> served as training cases for intercoder calibration. Interrater discrepancies were resolved by discussion until consensus was achieved. Transcripts were recoded iteratively until thematic saturation was reached. Table 2 lists the final coding schema, including definitions and examples. Modeling was not included as a teaching technique; teaching had to be explicitly verbalized and intentionally directed toward the resident to be counted.

### Statistical Analysis

$\chi^2$  Tests were used to compare the OR and the video-based coaching sessions by the percentage of teaching points initiated by the attending vs the resident and the response of the attending to resident-initiated points. Paired *t* tests were used to compare the mean counts of teaching points per hour, based on content and technique, between the OR and the video-based coaching sessions. For the coaching sessions lasting less than 1 hour, the time was rounded up to 1 hour rather than extrapolated. We performed a sensitivity analysis in which we limited OR time to the attending presence; results were similar, so only the original analysis is reported herein. Significance was set at 2-sided *P* < .05. All analyses were performed using statistical software (SAS, version 9.4; SAS Institute Inc).

## Results

A comparison of teaching points was made between the OR and the video-based coaching sessions with respect to initiator, content, teaching technique, and tone, adjusted for time. While

Table 1. Cases

Case	PGY Level
Exploratory laparotomy, diaphragmatic hernia repair	5
Ventral hernia repair	4
Total thyroidectomy	4
Abdominoperineal resection	5
Open splenectomy	5
Low anterior resection of rectosigmoid, end sigmoid colostomy, resection of endometrioma	5
Exploratory laparotomy, enterocutaneous fistula repair, end ileostomy reversal, small-bowel resection, enterocolostomy, partial colectomy, end colostomy, repair of colovesicular fistula	5
Open jejunostomy tube	4
Radical resection of retroperitoneal leiomyosarcoma, left nephroureterectomy, left colectomy, distal pancreatectomy, splenectomy, small-bowel resection, left partial adrenalectomy, omental pedicle flap	4
Exploratory laparotomy, biopsy of retroperitoneal tumor	4

Abbreviation: PGY, postgraduate year.

coaching, surgeons made more teaching points per unit time. Among 10 OR cases, we observed 1977 teaching points during 31.4 hours of video (63.0 per hour); in the coaching sessions, we counted 719 teaching points during 7.0 hours of video (102.7 per hour).

### Focus on Resident Education

While coaching, surgeons were more focused on resident education; they performed educational needs assessments almost 10 times more often (3.30 vs 0.28,  $P = .04$ ). Residents were better able to direct teaching to accommodate their own learning needs: 17% (331 of 1977) of teaching points were initiated by residents in the OR compared with 27% (198 of 729) in the videobased coaching sessions ( $P < .001$ ).

While coaching, surgeons asked almost 3 times more questions to prompt reflection or critical thinking (9.30 vs 3.32,  $P = .07$ ) and set 10 times more goals to facilitate future practice (2.90 vs 0.28,  $P = .11$ ). They also validated residents' experiences (eg, regarding the challenging nature of a case) more frequently (8.40 vs 1.81,  $P < .01$ ), thus softening critical feedback and increasing resident engagement (Table 2).

### Teaching Content

Anatomy (8.48 vs 3.10,  $P = .01$ ) and progress through the steps of the procedure (20.30 vs 7.50,  $P < .01$ ) were more commonly discussed in the OR. In the video-based coaching sessions, higher-level concepts—specifically, intraoperative decision making (mean, 9.70 vs 2.77 instances per hour,  $P = .03$ ) and failure to progress (mean, 1.20 vs 0.13 instances per hour,  $P = .04$ )—were more frequently discussed (Table 2).

### Increased Depth of Teaching

Teaching was less directive and more explanatory during video-based coaching; attendings preferentially used instructive techniques in the OR (24.48 vs 0.10 teaching points,  $P < .01$ ) and informative techniques while coaching (44.80 vs 31.05 teaching points,  $P = .20$ ) (Table 3). Attending responses to resident-initiated teaching points tended to be more thoughtful and

more thorough during the coaching sessions. In the OR, most attending responses were open (95.7% [310 of 324]), few were reflective (2.5% [8 of 324]), and fewer were closed (1.9% [6 of 324]). In the coaching sessions, while open responses predominated (82.8% [149 of 180]), reflective responses were common (16.7% [30 of 180]), and closed responses were nonexistent (0% [0 of 180]) ( $P < .01$ ) (Table 2).

Even when the same teaching point was made in both venues, it was generally more thoroughly articulated in the video-based coaching sessions. During a biopsy of a retroperitoneal mass, the resident asked about the approach and received a response that was informative but minimally so: Resident: "So you think we should go through [the] lesser sac here?" Attending: "Yeah, I think you need to get to that..." In the corresponding coaching session, the coach used several techniques—questioning, informing, and validating—to deepen the resident's understanding about intraoperative decision making surrounding the exposure:

*Coach: Where are your windows in the upper abdomen to...get back where that thing was? Do you remember what you were thinking about the different options for getting back there...?*

*Resident: ...We talked about going through the gastrohepatic ligament, which is more or less what we did in the end, right? Or we could have gone posterior to the stomach [because] we were going into the lesser sac; we could've kocherized the duodenum....*

*Coach: I think in this case it was easier to go through the gastrohepatic ligament because it was a direct route down to the thing. It was more to the right of the aorta than it was to the left.... Remember, we had this big discussion: where's the cava...? ...Two reasons why there's complex [anatomy]. (1) ...You just don't have good exposure because you're trying to do it through a tiny hole.... (2) You [have] just got tumor socked in there, and you just can't tell. So...you think about what things are going to be in that neighborhood and what you need to know. And you get a good sense of strategy and reassurance when you've clearly identified all the key structures. So we knew, "...Where is the cava?" because there were 2 options.... If the thing had pushed the cava posteriorly...we could have been coming down on the cava, which was not what we wanted to do. We thought the cava was anterior, right? ...Triangulate the scans. We thought we were pulling the cava up....*

### Reconciliation of Missed Learning Opportunities

#### Correction of Misconceptions

Often during the video-based coaching sessions, previously unrecognized gaps in residents' comprehension of a case came to light. One resident admitted confusion with the attending's instructions during the case: Resident: "I remember at one point you said to...kocherize the duodenum by feel, and I was like, 'No idea how to do that.'" Throughout the session, the coach set goals for this technique: choosing a relevant case for further practice, enumerating the steps, and stopping to further clarify points as requested by the resident (eAppendix in the Supplement, example 1).

Similarly, during a complex retroperitoneal sarcoma resection, the attending directed the resident through steps of the dissection without extensive explanation of the attendant

Table 2. Coding Schema

Code	Definition	Example
<b>Content</b>		
Preoperative decision making	Preoperative workup, operative indications, anticipated findings	"The radiologists think there's a side end to this conduit there that was involving the bladder. I think the bladder involvement is higher up.... If so, that's good for her because then it's in the small intestine.... On the endoscope, I did not demonstrate a fistulous connection, nor did I see mucosa. But I could insufflate the colon.... There must be a connection from something.... Something it connects to eventually gets to the colon. The colon looked like it was totally diverted. There wasn't any stool in it; there wasn't any bile in it."
Room setup	Patient positioning, draping, surgeon positioning or posture, lighting	"Honestly, a right-handed surgeon has an easier time in the pelvis from this side of the table."
Incision and exposure	Choice of incision, retractor positioning, dissection, identification of operative site	"So the thing about all the self-restraining retractors for a midline laparotomy that should be longer vertically than horizontally, you pretty much have to turn it into a rectangle to get good exposure. If you're talking about a kidney transplant, you can make it a circle. And for certain other things, like a hysterectomy, you can make it sort of horizontal. So this [is] kind of what you should be visualizing as you put in the Bookie [Bookwalter retractor]."
Anatomy	Identification of structures	"So here's [the] pancreas right here. Here is [the] splenic vessel. Here's [the] splenic artery, probably, right here. See how it branches here?"
Pathophysiology	Disease process, identification of abnormal structures	"Just some hemochromatosis from all her transfusions, which is probably why her liver looks so dark."
Progress	Steps of the procedure	"OK, so why don't we see if we can get around the artery here."
Failure to progress	Cessation of forward movement during the case, ideas or techniques for resuming progress	"I think everybody at this stage has a lot of what we call sort of spinning wheels, where your hands are moving, but the case isn't going forward. Where you're just kind of doing this, but nothing is actually happening.... Every movement you make should move the case forward." "That sort of slowed the operation down—ran into something we didn't recognize. Yeah, we thought, 'Is there a lumen there? What's going on? Is that a piece of stomach?' No [the] stomach's down over here.... But as it turns out, it was just ugly looking scar."
Technique	Psychomotor tasks, choice of instruments or sutures, tricks for perfecting existing skills or acquiring new ones	"But I actually think bovieing is better for lysis of adhesions than scissors because you see less bleeding, and the more bleeding you have, the greater the chance that you're going to either obscure your view or develop more adhesions down the road from the reaction to the blood."
Intraoperative decision making	Decisions about approach, handling unexpected findings, resection margins, etc	"Once we get the bladder more or less displayed, it's probably worth thinking about, should we have taken down the dome of the bladder to get that injury more exposed? You know, follow the dome and then down the right sidewall?"
Situational awareness	Consideration of available resources, interdisciplinary coordination	"So what I would do is.... 'Anesthesiologists, you ready?' Again, you can't suction out that blood, so...do you have 50 dry laps [laparotomy pads] ready? ...Is everyone on board? Because you are the commander of the team, you're the captain of the team, so you've got to let everyone know what to expect, what your plan is, and thinking like that."
Pitfalls	Risks, potential or real complications	"If the abdominal wall dries out, you can get fat necrosis, which increases the rate of infection."
Summarizing or reflecting	Reviewing existing data, knowledge, or completed steps	"So we found the enterovesical fistula. We still have a hole in the bladder that needs to be repaired. We have to rule out colovesical fistula."
Postoperative care	Wound care, diet, medications, drain management, activity restrictions, further workup or treatment	"Well [the] stomach's not too bad.... It's OK. You can avoid [a nasogastric tube].... And about 24-h [hemato]crits. I'd go with every 4 h for the first 24 h.... And then just text me the results, email me the results. And then she already got her vaccinations? So if she does OK, sips, she can probably start on some simethicone."
Educational needs assessment	Making statements or asking questions solely for the purpose of determining the learning goals of the resident	"Anything you want to work on or talk about or plan?"
<b>Teaching Technique</b>		
Instructing	Directing without explanation	"All right, now I want you to open toward me, wide as you can. Keep going, wide as...possible.... Now I want you [to] bring that with, and I want you to pull up."
Informing	Explaining, justifying, providing information	"The only good piece of fascia that we had to close this with anteriorly was the posterior sheath. And actually in the midline, we used both anterior and posterior sheath."
Questioning	Prompting reflection or critical thinking (does not include rhetorical questions)	"Now, let's say, it's really, really stuck, like you can't even get a plane between the dome of the spleen and the diaphragm. How are you going to mobilize that?"
Giving feedback	Responding to resident thought process, operative moves, or performance	Resident: "I'll just make it the size of the United States quarter." Coach: "In her, I think it might be a little too big."
Validating	Reassuring, normalizing of experience, war stories	"You know, I think learning how to set up the Bookie is one of the hardest things people learn—you know, one of the toughest skills you learn how to do. Probably because most of the time, the attending's doing it, instead of you guys." "Other than having to stop and repositioning the retractors every so often, I didn't think it made the operation unsafe, but it did slow things down. That's more my fault than yours because I was the one that wanted the oval ring."
Goal setting	Identifying ways to learn, practice, or reinforce in the future	"One thing we should do for the next case is...when you're taking down the superior pole, knowing exactly how much tissue to take with your clamp. Because if you take too little, it tears apart, and the vessel retracts.... If you take too much, then it's too much tissue."

(continued)

Table 2. Coding Schema (continued)

Code	Definition	Example
<b>Tone</b>		
Positive	Complementing, reinforcing good practices	"I think now you're at a point in your training where you can take charge a little more of the operation and use the right angle more to do that dissection. And I think that you have the skill set to do that. And now you just need the confidence to know that you're in the right plane."
Negative	Insulting, belittling, sarcasm, nonconstructive feedback	"[Sarcastically] You're doing a great job. I'm so happy to work with you.... You're making great progress. [Whispering] We're being watched for coaching."
Neutral	Neither positive nor negative	Coach: "So you have no proximal vascular control, and you know you've got a lot of adhesions that are probably going to bleed. How do you manage that? Or what would your intraoperative strategy be?" Resident: "Kind of do permissive hypotension. I don't know if that helps anything." Coach: "Nope, make[s] coagulopathy worse."
<b>Response to Resident Initiation</b>		
Open	Answering with explanation	Resident: "We're [going to] leave his GORE-TEX [expanded polytetrafluoroethylene] in?" Coach: "Yeah, it's not infected."
Closed	Minimally answering without explanation	Resident: "Do you want me to maybe get one of those pouches?" Coach: "No, no, no."
Defensive	Aggressively responding to perceived threat or insult from resident	Resident: "At this point, I want to struggle a little bit more." Coach: "Right.... How do you think you're going to do that next year when you're a fellow, and you have to operate with residents? Would you do that?"
Reflective	Rethinking of prior explanations or events	Resident: "I didn't understand what you meant by, you know, putting a couple of interrupted in to bring that together. But the point was that could sort of stay out of our continuous suture, right?" Coach: "Right, right. [Be]cause we still wanted the patch to be sewn in position with all interrupted sutures, and we wanted it to be well anchored in the midline. Honestly, we probably didn't have to do 3 sutures to anchor it in the midline, but we had that much mesh, and, you know, it was—if we look at it from below, sort of have the V there, and then the other side of the V, and we have 3 stitches, I think, bringing it together. That just sort of made a nice continuation with our mattresses on the sheath. We could have just, you know, just not done the V, brought this here, left the crumple, and cut some of that out, but I think it works just as well one way or the other."

decision making. The resident did not interject but asked for clarification during the coaching session: Resident: "I'm just looking at...taking down the transverse colon. Did we do that just for...retraction at the point?" The coach then used a mixture of questioning and informing to explain the relevant anatomy and intraoperative decision making (eAppendix in the [Supplement](#), example 2).

Without coaching, these residents would have missed nuances of the critical decision making required for the cases. Learning opportunities would have been lost.

#### Retrospection

Post hoc coaching allows for retrospective insight. With knowledge of pathology report results, an attending was able to reflect that the open approach had given them tactile feedback that changed the operation and hence the patient's prognosis (eAppendix in the [Supplement](#), example 3). Similarly, in reviewing a jejunostomy tube placement (a procedurally straightforward case), the resident and coach reflected on the postoperative death, initiating a novel discussion about decision making in the setting of terminal disease (eAppendix in the [Supplement](#), example 4), a topic often neglected in surgery.

#### Hypothetical Scenarios

Coaching also allowed for the discussion of theoretical complications. In the case of a splenectomy, which "turned out to be the perfect, ideal situation," the attending used the coaching session to review alternate scenarios "if it [had not been] so safe and clean." The attending questioned the resi-

dent about anatomic and pathophysiological issues, technique, and potential intraoperative pitfalls (eAppendix in the [Supplement](#), examples 5, 6, and 7). Such one-on-one personalized discussion of intraoperative management remains rare in today's training paradigm despite being critical to everyday practice.

#### Technical Learning

Increased depth was seen during coaching not just when teaching higher-level concepts, such as decision making. It was also seen when reinforcing basic psychomotor principles, such as posture or knot tying (eAppendix in the [Supplement](#), examples 8 and 9).

#### Educational Value

Attendings and residents expressed sentiments that coaching was educationally valuable in a way that complemented but was not redundant with the intraoperative experience. Both referenced the pressure they perceive to avoid consuming OR time with teaching:

*Resident: You get different feedback, and it's nice...for me to sit here and watch you go to different things than you might otherwise mention in the OR.*

*Coach: And you get more time to ask questions.... You don't feel like, "Well, we have to finish this operation, and I'll learn about this later." Well, now it's later, and we can go more in detail.... Video reviews are fantastic teaching tools.... It would be great to make the videos available for the residents to review whenever.... [The resident could] look at this and say, "Here's how I did it last time. I'm going to do another one of these next*

week.... How do I want to get ready?" ...If another resident is going to do one of these next week...[the resident] could say, "Hey, you should look at this video...that [the attending] did with me. He'll probably do it the same way. You'll be ready." I think there's a lot of learning opportunity here.

## Discussion

The International Coach Federation defines coaching as "partnering with clients in a thought-provoking and creative process that inspires them to maximize their personal and professional potential."<sup>25</sup> A novel concept in surgical education, coaching has been studied in limited settings, most of them simulated and all centered around a discrete skill set. Small randomized controlled trials have shown that coaching improves technical assessment scores in medical students<sup>26</sup> and junior orthopedic residents,<sup>27</sup> as well as nontechnical skill scores in senior surgical residents during simulations.<sup>28</sup> Bonrath et al<sup>29</sup> conducted a randomized controlled trial of video-based coaching on laparoscopic jejunostomies; coached residents scored higher on technical assessments. Case volume, the classic proxy for technical competence, correlated with scores only in coached residents; without a coach's interpretation and feedback, additional operative experience seemed to make no contribution to residents' technical learning curve.

In our application, video-based coaching demonstrated usefulness in teaching a variety of topics, technical and nontechnical. It was efficient, requiring only 1 hour (often less) of surgeons' time, with minimal preparation, and delivering greater than 50% more teaching points per unit time than operating. While one might anticipate that more teaching would occur merely because of the absence of concurrent clinical responsibility, the intervention's primary value lies in the individualization, depth, and quality of instruction.

While coaching, attending surgeons were more likely to perform educational needs assessments, and residents were more likely to initiate teaching points than they were in the OR. According to adult learning theory, education that is centered around the learner is more likely to motivate practice change.<sup>30,31</sup> Cox and Swanson found that one of the largest differences between superior and mediocre surgical teaching was "awareness and sensitivity to resident learning needs."<sup>32(p252)</sup> Yet, only 18% of general surgery residents nationally report that faculty help them identify their personal educational operative goals.<sup>33</sup> Residents' learning needs cannot be assumed given the disparity between residents' and attendings' OR educational priorities.<sup>34</sup> In adherence with these principles, we did not dictate content for the video-based coaching sessions; therefore, our intervention contrasts starkly with other studies of coaching for surgical trainees, in which learning goals were predetermined. Indeed, in their interviews of surgeons, Mutabdzic et al<sup>35</sup> found that a major barrier to coaching was surgeons' fear of losing control over their learning agenda. As pointed out in the editorial<sup>36</sup> accompanying that article, such self-determination is actually the goal of coaching; the impor-

**Table 3. Teaching Points per Hour in the Operating Room (OR) vs the Video-Based Coaching Sessions**

Variable	Count, Mean		P Value
	OR	Coaching Session	
<b>Content</b>			
Preoperative decision making	1.28	1.30	.97
Room setup	0.71	1.10	.50
Incision and exposure	7.11	8.50	.63
Anatomy	8.48	3.10	.01
Pathophysiology	3.70	5.10	.46
Progress	20.30	7.50	<.01
Failure to progress	0.13	1.20	.04
Technique	12.98	14.30	.76
Intraoperative decision making	2.77	9.70	.03
Situational awareness	0.54	1.10	.13
Pitfalls	5.05	5.20	.95
Summarizing or reflecting	2.51	4.00	.19
Postoperative care	1.77	0.90	.23
Educational needs assessment	0.28	3.30	.04
<b>Teaching Technique</b>			
Instructing	24.48	0.10	<.01
Informing	31.05	44.80	.20
Questioning	3.32	9.30	.07
Giving feedback	7.04	7.40	.89
Positive	2.79	4.10	.44
Negative	0.24	0.00	.34
Constructive	2.33	1.50	.41
Validating	1.81	8.40	<.01
Goal setting	0.28	2.90	.11

tance of residents' input in defining their learning goals cannot be underestimated.

Residents across the country describe communication as a key attribute of a great teacher.<sup>37</sup> However, by our count, instructing—directing without explanation—comprises a large proportion of the teaching in the OR. This finding is consistent with a study by Chen et al<sup>38</sup> of surgical videos, in which most intraoperative guidance was in the form of directing. After analyzing videorecorded operations, Roberts et al concluded that such "instrumental" interactions, in which the attending directs the resident through various actions without explanation or guidance, "may be lost opportunities for deliberate education."<sup>23(p649)</sup> We found that surgeons less frequently used instructing and more frequently used informing while coaching; hence, video-based coaching enabled surgeons to reconcile the "lost opportunities" in the OR described by Roberts et al.

Prior observational data have shown that technical steps are more frequently taught in the OR than decision-making ones.<sup>39</sup> Similarly, we found that anatomic principles and operative steps were more commonly taught in the OR. After interviewing surgical attendings and residents about intraoperative learning, Cope et al concluded that such factual knowledge is "suitable for the junior learner."<sup>22(p1126)</sup> The tendency to simplify the teaching in the OR may reflect sur-

geons' (necessary) preoccupation with operating while in the OR. In their human factors analysis of intraoperative teaching, Lio et al<sup>40</sup> hypothesize that trainees expend so much mental effort on the primary task of operating that there is no remaining processing ability to continually assess and plan upcoming steps. Our coaches shifted focus to more advanced topics— intraoperative decision making and failure to progress— during video review, again demonstrating that teaching opportunities missed in the OR may be recaptured with coaching. Moreover, coaches continued to teach technical skills, implying usefulness of coaching at all levels.

Cope et al described a novel educational theme of “sensory semiosis,” or “learning to interpret visual and haptic cues.”<sup>22(p1127)</sup> They noted that such cues “can seldom be adequately simulated”<sup>22(p1129)</sup> and advocated intraoperative video review for visual training. Of surgical residents with access to videorecording, 94% reported that it was a helpful educational tool.<sup>33</sup> Video is a known trigger for “reflection on action.”<sup>30</sup> However, we warn that video review alone is not enough; the expertise of a coach in facilitating reflection is critical. While residents increased the rate at which they initiated teaching points during the coaching sessions, most were initiated by the coaches. In the study by Bonrath et al,<sup>29</sup> only coached residents' self-assessments correlated with those of experts, indicating that coaching improves the accuracy of self-reflection, a skill vital to lifelong learning.

Given well-established disparities between attendings and residents in their perception of teaching,<sup>37,41-43</sup> the objective measurement of teaching points by third-party observers was a methodological strength of our study. The use of videorecording and audiorecording further increased the accuracy and reproducibility of coding. Our mixed-methods approach combined statistical significance with a level of granularity only achievable through qualitative analysis. Our data set of 10 cases, representing more than 31 hours of intraoperative time, is considerable in qualitative research. In dealing with the coaching sessions that lasted less than 1 hour, we used actual counts and

did not extrapolate them over the unused time; as such, our results are biased against coaching.

### Limitations

There are several limitations to our study. It was conducted at a single academic tertiary care hospital, which may limit generalizability. Operating room videos may have failed to capture all preoperative discussions between attendings and residents. Because we most frequently started recording before the arrival of the surgeon, we captured several such conversations. Pernar et al<sup>44</sup> observed that attendings and residents were simultaneously present before surgery in only 18.5% of cases, reassuring us that we missed few such teaching moments. The Hawthorne effect is always a concern in observational research, but it applied to both the OR teaching and the video-based coaching sessions. We do not have baseline data on intraoperative teaching at our institution; however, we did not notice a qualitative difference between the teaching in these cases and in those that we previously recorded to answer other research questions. In all except 1 session, attendings were coaching for the first time; because they were unaware of the structure or content of the coaching session at the time of the operation, they could not have anticipatorily altered their intraoperative teaching.

### Conclusions

Video-based coaching is a novel and feasible modality for supplementing intraoperative learning. It is particularly useful for individualizing instruction and feedback to each resident, increasing the depth of what is taught, and teaching higher-level concepts, such as decision making. Requiring only videos, which are easily obtainable with standard laparoscopic equipment, and minimal preparation from surgeons, we believe that video-based coaching is an easily replicable and effective educational intervention.

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