Can a Structured, Video-Based Cadaver Curriculum Demonstrating Proficiency Enhance Resident Operative Autonomy?

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INTRODUCTION: Autonomy is of foremost concern in the current era of surgical residency, and it is especially important to trainees when considering their surgical education. Factors impacting trainee independence include the restriction of clinical work hours and the development of advanced minimally invasive techniques such as robotics, which requires separate technical education outside of conventional surgical education. Moreover, when residents are left to learn fundamental exposures via their clinical experience alone, they run the risk of not being exposed to some fundamental skills based on case volume and type. The Department of Surgery at Emory University developed a cadaver-based simulation curriculum to standardize exposure to fundamental operative skills and enhance proficiency outside the operating room, with the larger aim of improving resident autonomy.

METHODS: Residents were assigned to small groups led by a chief resident with an even distribution of postgraduate year (PGY) levels. Each group participated in core surgical exposures and fundamental maneuvers on a cadaver over a 6-hour session. Residents were tested on skills according to their PGY level about 1 month after the course. Testing included recitation of the skill in an oral boards format, highlighting major steps, followed by performance of the skill. All steps were video-recorded with no resident identifiers. These were reviewed by 2 independent, blinded faculty examiners who assigned proficiency grades to each resident video.

RESULTS: Three hundred and thirty-three individual procedure evaluations were done over the 5-year period. Senior residents (PGY3-5) had 86% pass rate while junior residents (PGY1-2) had 70% pass rate. Overall, 21% of residents failed to achieve competence in their assigned skills. Junior residents were less likely to achieve competence compared to senior residents. Faculty graders had improved congruence in grading as the course progressed through the 5 years. The most recent 2 years had >80% congruence in faculty grading compared to less than 50% congruence in the first 2 years. 81% of attendings agreed this course positively influenced the granting of autonomy in the operating room.

CONCLUSIONS: A cadaveric skills course focused on fundamental maneuvers with objective confirmation of achieving competency is a viable adjunct to clinical operative experience. Video-recorded evaluation, of these fundamental skills improved both resident and attending confidence in trainee operative skill. (J Surg Ed 76: e152−e160. © 2019 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Surgical education, Resident autonomy, Surgical skill proficiency, Simulation curriculum

COMPETENCIES: Patient Care, Medical Knowledge

INTRODUCTION

Resident autonomy is critical to transition from being a surgical trainee to independent practice, and there is a significant concern among educators that current residency paradigms detrimentally limit autonomy.[1,2] This perception[3] is multifactorial, with increased supervisory guidelines, modern hospital policies, litigation, and changing public expectations of the health system

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playing substantial roles. Other factors include case complexity, the increasing application of advanced technologies such as robotics, and consolidation of hospital systems which alters the amount of time a trainee spends rotating with proctoring faculty.[4] Faculty experience with a trainee in any specific case has been often quoted as the strongest predictor of granting autonomy[5] while some recent data suggests that consonant personality traits and familiarity may play a greater role.[6] Increasing attention is being directed toward methods to augment autonomy in surgical residency, foremost being chief resident run services.[7,8] The Department of Surgery at Emory University developed a cadaver-based simulation curriculum to demonstrate technical proficiency [9] with the intention of creating an objective measure of competence. This program sought to provide trainees confidence in their skill set and to provide faculty with a priori knowledge of a trainee's technical ability. No standardized model of testing operative proficiency of surgical trainees currently exists[10] and even faculty credentialing fails to utilize objective skills assessment. Some studies using directed coaching for surgical attendings[11] based on video-recorded skills[12] have been demonstrated to improve surgeon performance. However, these studies were not designed for assessing proficiency, nor were they directed toward residency-level surgeons. Simulating an operating room of an independently operating surgeon, a program was developed that involved learning fundamental surgical skills followed by blinded assessment of these skills for surgical residents at Emory University. The curriculum was designed keeping in mind the need to teach 30 key fundamental maneuvers (Supplemental Table 1). Currently there is no formal curriculum that the authors are aware of, that tests for resident technical skills in such a broad manner.

METHODS

Group Cadaver Dissections and Teaching Sessions

All categorical and preliminary residents at the Emory University General Surgery Residency Program were enlisted. Residents were assigned to small groups of 7 to 8 residents, led by a chief resident and an attending, with an even distribution of postgraduate year (PGY) levels. Each group participated in core surgical exposures[13] and fundamental maneuvers (Supplemental Table 1) on a cadaver over a 6-hour session. Residents were expected to be knowledgeable in all skills listed for their PGY level and below. Each group was provided with a guide that outlined the general order in which to proceed with these skills to maximize educational content, while remaining efficient in the process, as well as to minimize educational variability between the groups. Residents were expected to prepare for this session and be able to verbalize the key steps for the skill in an oral boards format. While performing the skill, residents pointed out key anatomy particular to that skill. Commensurate with clinical and operative responsibilities in our residency program, PGY1-2 residents were designated as junior residents, and PGY3-5 residents were designated as senior residents. For residents on research sabbaticals, cadaveric tasks were assigned based on the postgraduate clinical year, they would be placed in when rejoining the clinical training program.

Testing and Grading

One month after the cadaver dissection teaching sessions, residents were individually tested on skills according to their PGY level. Residents were given protected time from clinical duties to do the assessment. Immediately prior to testing, residents were given a card listing one of the skills according to their PGY level (Supplemental Table 1). Testing included recitation of the skill in an oral board format, highlighting all major steps, followed by the performance of the skill with the identification of key anatomical landmarks and structures. Residents had 20 minutes to recite and perform the skill indicated on their test card. The entire process was video-recorded using 2 cameras (except for year one when one camera was used), one of which was a high definition camera directly above the operating table, and the other was from the side of the operating table. These blinded videos were sent for grading to 2 independent faculty reviewers (Table 1). The faculties were provided a grading rubric modeled upon the Objective Structured Assessment of Technical Skills[14,15] (Supplemental Figure 2). Each resident was given a pass/fail grade for achieving competency in the assigned task. In order to obtain proficiency in their designated skill, the trainee needed a passing evaluation from both faculty graders (pass/pass). Receipt of a failing evaluation (either pass/fail or fail/fail) resulted in a resident being placed in the remediation pathway.

Training of Evaluators and Remediation

Self-reported interest in surgical education by faculty members was used as the selection criteria for choosing evaluators for this curriculum. The original 16 evaluators stayed constant for the first 4 years of this curriculum with additional evaluators being added in the fifth year. Standard Likert scales (based off OSATs) (Supplemental Figure 1) which had been internally validated at Emory were utilized for grading. The Emory Surgical Education Committee, comprised of both residents and faculty,

TABLE 1. Listing of all Faculty Graders Who Assessed Video-Taped Cadaveric Dissection Sessions

Table 1a. Profile of Faculty Graders 2014-2019

	Surgical Sub-Specialty/ Focus of Practice	Years in Practice/	Fellowship Trained	Years Cadaver Assessments Done
Faculty 1	Colorectal Surgery	8	Yes	5
Faculty 2	General/Bariatric/MIS	14	Yes	4
Faculty 3	General/Bariatric/MIS	12	Yes	5
Faculty 4	General/Bariatric/MIS	6	Yes	5
Faculty 5	General/Bariatric/MIS	5	Yes	5
Faculty 6	General/Endocrine Surgery	13	Yes	4
Faculty 7	General/Endocrine Surgery	5	Yes	5
Faculty 8	Pediatric Surgery	9	Yes	4
Faculty 9	Pediatric Surgery	5	Yes	5
Faculty 10	Pediatric Surgery	5	Yes	5
Faculty 11	Surgical Oncology	14	Yes	5
Faculty 12	Surgical Oncology	7	Yes	5
Faculty 13	Surgical Oncology	7	Yes	4
Faculty 14	Trauma Surgery	15	Yes	5
Faculty 15	Trauma Surgery	6	Yes	5
Faculty 16	Vascular Surgery	8	Yes	5

Table 1b. Profile of Additional Faculty Graders 2018-19

	Surgical Sub-Specialty/ Focus of Practice	Years in Practice/	Fellowship Trained	Years Cadaver Assessments Done
Faculty 17	Acute and Critical Care Surgery	16	Yes	1
Faculty 18	Acute and Critical Care Surgery	13	Yes	1
Faculty 19	Acute and Critical Care Surgery	1	Yes	1
Faculty 20	Acute and Critical Care Surgery	3	Yes	1
Faculty 21	Acute and Critical Care Surgery	1	Yes	1
Faculty 22	Pediatric Surgery	21	Yes	1
Faculty 23	General/Bariatric/MIS	1	Yes	1
Faculty 24	Surgical Oncology	1	Yes	1

developed the list of skills to be covered in the course, and created general guidelines for the evaluating faculty for determining proficiency. In the first year of this course, a single faculty member evaluated 3 to 4 videos and gave the residents feedback via standardized metrics that culminated in a "pass or fail" designation. The first year of this endeavor was not accompanied by any structured remediation. For the second year, a remediation plan for residents was created for residents who received a failing evaluation. To better "train the graders" and enhance standardization, pass/fail examples from the first 2 years were used to create a repository of pass/fail examples that could be used as a reference for grading faculty. Six sets of paired faculty reviewers were assigned between 7 and 9 videos to separately review and score independently of one another. As each video had 2 scores, these were examined for reviewer concordance. If the resident score included any fails (fail/pass or fail/fail), the senior author (JKS) reached out to faculty to request, they review the video again and indicate comfort with a failing score. This process of paired grading and verification of remediation designations continued for all years of the course going forward. All participating residents were sent a formal letter with their grade designation as well as detailed feedback from the graders. Moreover, residents were sent links to their video so they could review their own performance. Remediating residents were required to review their videos with their assigned faculty advisors to better understand the knowledge or technical issues that led to their remediation designation. To ensure that the cadaveric dissection grade was not highlighting a more systemic failure in the resident's technical skills, the remediating residents were also required to attain 3 operative evaluations demonstrating PGY-level appropriate proficiency over a 2-month period from any faculty using the same grading scheme (Supplemental Figure 1).

Resident and Attending Opinion Surveys

At the end of each academic year, residents and attending surgeons (who participated in the course as instructors or graders) were administered a survey with responses measured on a 5-point Likert scale (Supplemental Figures 2 and 3). Questions were geared toward determining the appropriateness of the tested skills, the

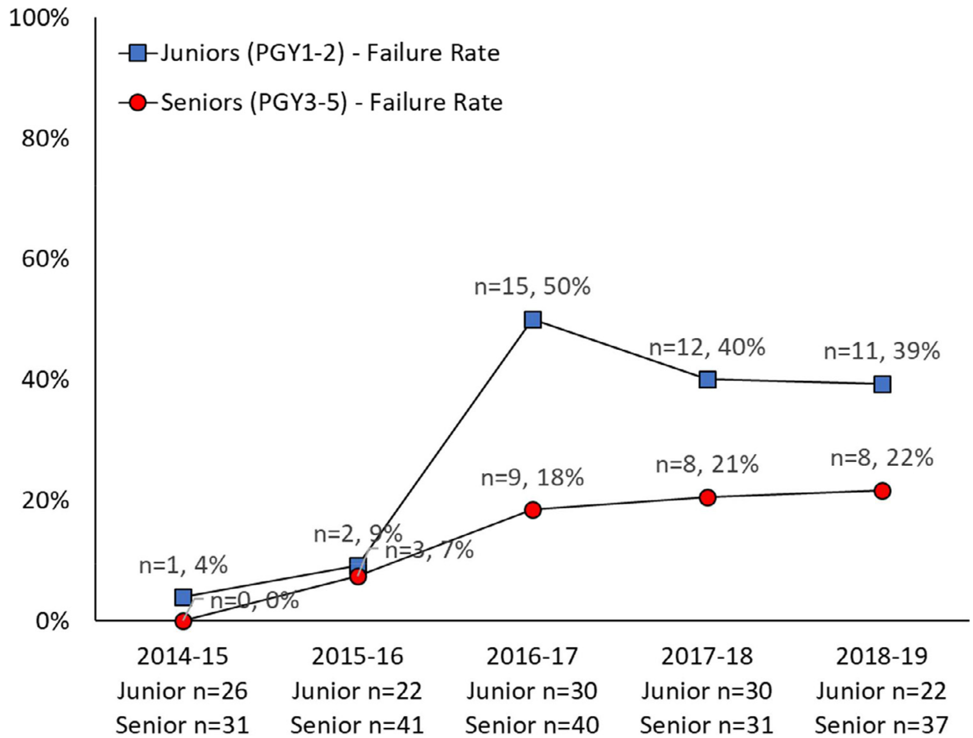

FIGURE 1. Overall numbers of trainees who failed the cadaveric video assessment in each year, stratified by PGY status. Overall a significantly higher proportion of junior residents failed the cadaver dissections assessments (chi-square statistic 10.95, $p < 0.001$).

adequacy of the simulated technical education, and satisfaction with the overall structure of the course. Modifications to the educational structure of the instructive dissection sessions and testing sessions were made annually based upon feedback.

Funding and Institutional Review Board

Exemption was granted for this study by the Emory Institutional Review Board as this was considered an educational quality improvement project. Funding for the study was provided through the educational funds of the Department of Surgery. The body donation program at the Emory University School of Medicine was utilized for obtaining fresh cadavers.[16]

RESULTS

Resident Participation and Skills Tested

A total of 143 surgery residents participated in the cadaver-based simulation curriculum over the past 5 years. Of these, 112 were categorical general surgery residents (PGY1-5) and nondesignated preliminary general surgery residents (PGY1-2). The remaining were from urology (PGY1, n = 20), integrated thoracic surgery (PGY1-3, n = 11), and integrated plastic surgery (PGY1-3, n = 10). Skill testing at each PGY level has remained similar, with these exceptions: 1) addition of axillary dissection and groin vascular exposure to the PGY3 level starting 2015-16, and 2) removal of bowel anastomosis from all levels starting 2015-16 secondary to redundancy with a separate residency bowel anastomosis course.

Proficiency Testing

Three hundred and thirty-three individual video evaluations were completed. One hundred and thirty-six were performed for junior residents and 197 for senior residents. Junior residents had an average failure rate of 30%, while senior residents had a significantly lower failure rate (14%) (Chi-square 12.4, $p < 0.001$). Figure 1 graphs the year-by-year failure rate for the junior and senior residents. Failed video grader comments were reviewed to determine primary causes for failing. The failures were divided into 3 main groups: (1) poor technique as observed on the video recording, (2) lack of knowledge about the procedure or insufficient anatomical knowledge, and (3) omission of highlighting the critical structures during the video or not following specific task instructions. Figure 3 illustrates the number of residents who failed year-by-year, stratified by indication for failure. A significantly higher proportion of senior resident fails (89%) were due to poor technique compared to the junior residents (63%) (chi-square statistic 5.76, $p = 0.016$). Conversely, only 11% of senior residents

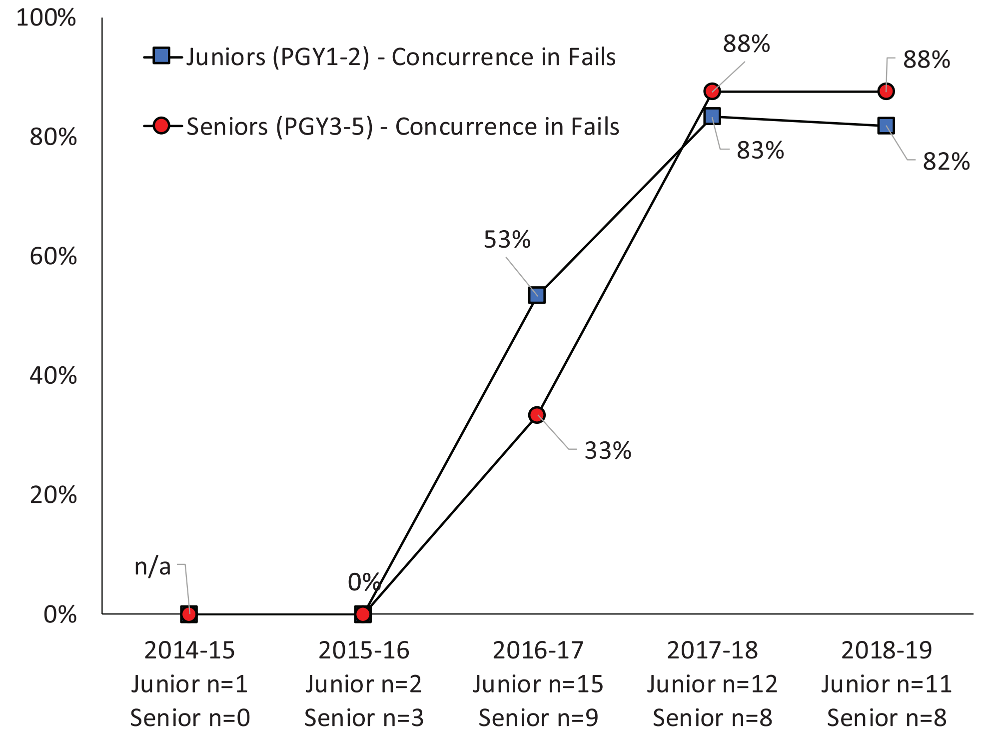

FIGURE 2. Congruence correlation for cadaver dissection graders. The congruence in assessment improved to 53% in the 2016-17 academic year to 84% in the 2017-18 year.

who failed the cadaver assessments did so due to the lack of knowledge or the inability to describe the appropriate anatomy compared to 37% for junior residents over the 5-year testing period.

Inter-rater Reliability

Figure 2 graphs the year-by-year congruency in examiner fail rates for junior and senior residents. While 2014-15 had only a single grader, 2015-16 academic year displayed a low level of congruency in examiner grades. The inter-rater reliability in examiner grades improved to greater than 80% for the last 2 years of testing for both junior and senior residents.

Confidence in Skill Performance and Autonomy Ratings

After the completion of this curriculum, resident confidence in completing the assigned skill independently

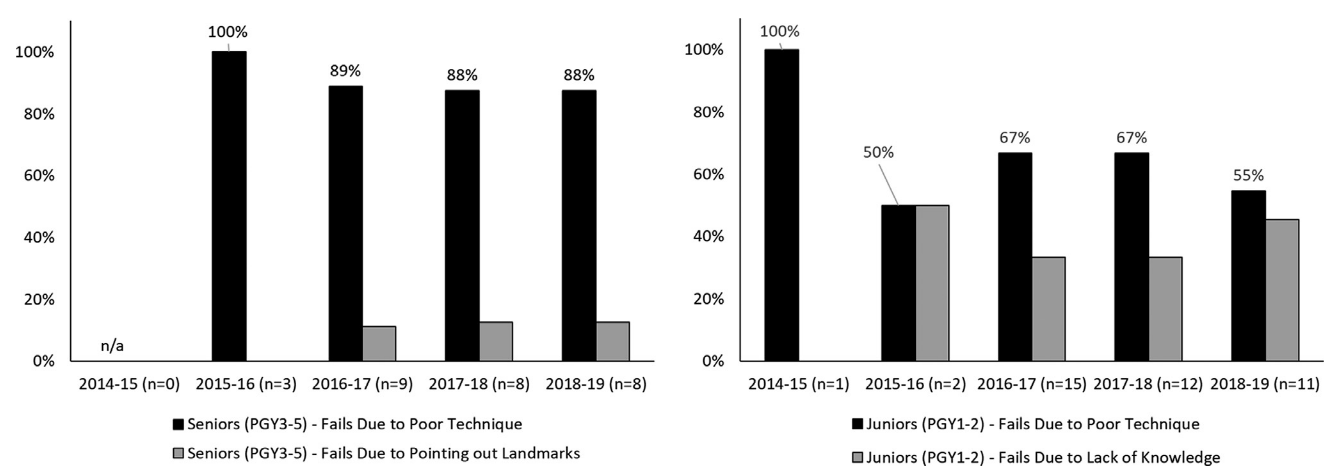

FIGURE 3. Percentage of senior **(a)** and junior **(b)** trainees who failed to achieve competency in their designated tested skill by reason for failure. Overall 89% of seniors and 67% of juniors failed due to poor technique. No seniors failed due to lack of procedural or anatomical knowledge however 33% of junior residents failed because of this. The remaining seniors failed because of failure to follow instructions with regards to individually pointing out key landmarks.

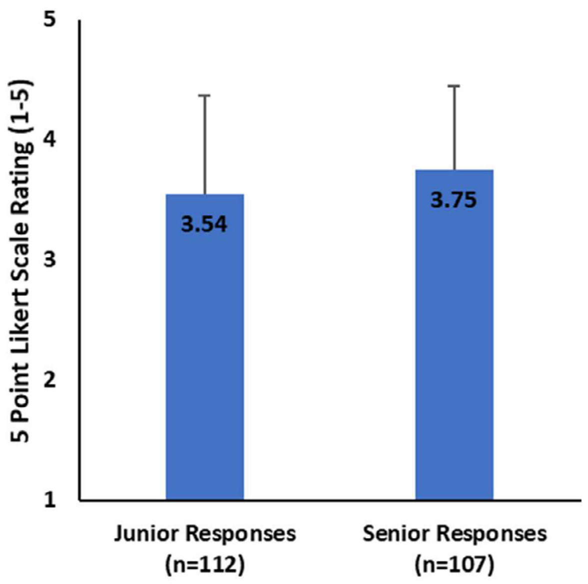

FIGURE 4. Confidence in ability to perform procedures independently by residents on a 5-point Likert scale. senior residents related taking the video recorded skills evaluation course with increased perceived ability to perform procedures independently compared to junior residents ($p = 0.03$).

was measured at 3.64 (±0.78) on a 5-point Likert scale. Senior residents had a higher perceived ability (3.75 ± 0.70) to perform procedures independently compared to junior residents (3.54 ± 0.83) ($p = 0.03$) (Figure 4). When attendings were queried using the same 5-point Likert scale to define their probability of granting increased autonomy to residents due to this curriculum, 81% responded in the affirmative. The attending response (3.2 ± 0.99) regarding the impact of the simulation curriculum on the actual operative autonomy granted was, however, comparably lower than resident's personal confidence in autonomous ability.

DISCUSSION

While most agree that there is erosion of resident autonomy in the current era of surgical training, the proposed solutions to this problem have varied. Procedural target numbers are not an effective way to evaluate resident competency for surgical procedures as has been discussed before.[17] This study posited that early exposure of residents to fundamental general surgical maneuvers would enhance their confidence in operative autonomy, and we accordingly organized a cadaver-based simulation curriculum. The hypothesis driving this curriculum also advocated that informing the faculty of this program would provide an objective method to encourage more independence in the operating room.

Evaluation Experience

This curriculum has now been in place for 5 years with a standardized template of surgical maneuvers, and procedures. The implementation of this curriculum was a learning experience in its pilot year on multiple fronts. We recognized that a single evaluator was not enough to have confidence that the assessment was not the function of individual bias, and thus switched to dual reviewers in the second year. The first year of dual reviewer use demonstrated divergent results for pass/fail assessments for half the residents. However, over the next 3 years, there was almost 80% to 90% congruency in the results of the examiners. The authors believe this initial discrepancy reflects a learning curve to viewing and grading these videos for specific technical metrics. The current graders now have 5 years of experience with greater than 35 video critiques each to date based on the increased intragrader congruence, we started observing in academic year 2016-17, we have estimated it takes approximately 20 video reviews to minimize intergrader variability of educational assessment. The first academic year 2014-15 stands out as an anomaly, given only a single resident failed to achieve competency. The authors believe this result is secondary to the fact that at the initiation of the course, the graders had no specific training to orient them to video critique and no relative baseline for a pass/fail performance. Through the repeated use of the same graders, "hands on" curricular training occurred.

Video Recording Technique

The first 2 years of this program had videos recorded using a single camcorder. Starting in third year a Karl Storz Visitor1 camera was added for an additional view. The Karl Storz Visitor1 was replaced with a Karl StorzVITOM HD camera in the fourth year. The feedback regarding Karl StorzVITOM HD use was very encouraging and it negated the need for a second camera. In the fifth year only the Vitcom with audio plugged into it was used for recording. The improved quality of audio-video recordings was commented upon by all graders in the last 2 years. Specifically the reduction in the variance of the video recordings was noted to enhance the overall curriculum grading experience.

Achieving Competency

Our initial 5-year experience identified that technical skill failure accounted for 64% of the junior resident fails, this was despite the demonstration of excellent procedural knowledge during their oral recitation. The remainder of junior residents (36%) failed to achieve competency secondary to insufficient procedural or anatomical knowledge, which subsequently contributed to poor technical performance or inability to translate into technically adequate dissections. Early identification of this disconnect is critical to encouraging increased exposure to the correct procedural knowledge and technical skills. The authors believe the identification of these deficiencies in junior years is critical, when competing clinical duties may force these residents to have less exposure to the operating room. The number of seniors who failed to achieve competency was less than 15% of the overall senior resident pool. Of these 69% were PGY3s and 27% PGY4s. Only one chief resident failed to achieve competency in 5 years. Lack of procedural or anatomical knowledge was not a reason for failure for any of the senior residents. Poor technique was the overwhelming (89%) reason for fails in this small group of senior residents. Grader feedback on these failures demonstrated that the failures were largely errors of "sophistication" such as instrument selection or strict tissue handling concerns. The remaining senior fails were due to either inability to comply with instructions or failing to point out the key landmarks identified as critical to the completion of a specific skill. The evaluation criteria were the same for all PGY levels. We specifically used standardized grading scales to prevent deviations in evaluation criteria. The discrepancy between junior and senior residents affirms appropriate progression through the training period and increased technical competence with increasing PGY-level.

Validating Testing Results and Remediation

Testing is an essential component of any simulation curriculum. Moreover, validating the testing model is critical to its efficacy. A uniform grading scale and clear objective parameters were paramount to the success of a simulation course of this magnitude. Our residents receive 2 cadaveric video evaluations through this program per year. A total number of 20 video-recorded sessions of component evaluations for each resident would be in line with recently published data on observations for determining surgical competence,[18] but achieving such a number in a simulation environment would be challenging even to the best resourced training programs. Therefore, we propose using this cadaver simulation curriculum as an adjunct to training by introducing residents to the concept of self-evaluation through a video review of one's own technical performance as well as emphasizing granular and specific technical feedback on the part of the training faculty. Another advantage of the video−recorded-blinded evaluations is the removal of personal bias when making assessments.[19,20] Since resident promotion was not linked to the results of this program, the faculty were not hesitant to fail residents. This project was purposefully designed with failure to be a positive result—as the leadership at this program believes that remediation would increase the one-on-one attention and feedback that a trainee would receive. Indeed, one could extend the lessons learned from cadaveric video skills assessments by applying the same rubrics to video assessments of operations performed during regular clinical rotations. When one considers that private and academic practices are increasingly requesting to view the skills of their future partners, we would be better preparing our trainees by routinely exposing them to these methods.

Training Framework

We have demonstrated a working framework for a formal surgical proficiency testing curriculum for trainees. The utilization of video-recorded surgical skills that are then formally assessed through standard rubrics is a useful adjunct to improving trainee confidence in surgical skills. The additional value of a curriculum of this structure is the enhanced autonomy that residents may be afforded because of familiarity with these designated procedures through structured repetition. Unlike a clinical rotation, where exposure to maneuvers is dependent on the cases booked, this curriculum repeats the same set of fundamental component tasks by design. A resident-in-training can be guaranteed that they will review all "core" skills in a cadaveric model every year of their residency.

Correlating Testing Results with Operating Room Experience and Remediation

While the video-recorded assessments have not been utilized for resident promotion, it is not unreasonable to consider using structured technical video assessments to this end. We do not currently have enough data from single video evaluations to suggest that trainees with poor performance on the skills evaluation can be linked to consistently poor technical performance on clinical rotations. In the period prior to this curriculum concerns regarding the technical skills of residents were based off subjective consensus of the promotions committee. After the creation of this course, we created a formal pathway for remediation where residents get flagged for poor technical skills based on the video ratings. We have been able to identify residents earlier in training who may require more skills training or supervision in the operating room, something which may have been missed in the past altogether at the junior level. Though we have to clarify that we have not yet identified an objective and repeatable tool to link good dissection skills as observed on video-recorded evaluations with good technique in the operating room. However, the authors believe this is a function of low numbers of video-recorded evaluations. The survey results from

TABLE 2. Notable Lessons Learnt Over 5-Years in Structuring a Cadaver Based Surgical Simulation Curriculum

1	Group sizes need to be limited to 6-8 with a standardized educational format to have a uniform experience
2	Assigning specific individual residents to dissections improves ownership and experience for all.
3	Practice sessions prior to actual dissection are critical to optimizing the educational experience
4	Anticipation of required dissection material prior to sessions (e.g., Rummel tourniquets, chest tubes) and organization of skills (neck dissection before thoracotomy etc.) such that a single cadaver can be used for multiple testing
5	High fidelity audio/video recordings are required to make testing results reliable.

both residents and attendings validated the utility of a curriculum like this with both groups overwhelmingly agreeing that this has promoted resident autonomy.

Limitations

One of the limitations of the current study was the inability to temporally link objective autonomy scores[21] to participation in this curriculum. The survey of attendings at the end of each simulation curriculum year indicated that trainees would theoretically be offered more autonomy. However, our current study was not designed to study the impact of such perceptions by the attendings on objective trainee autonomy in the operating room. Utilization of social media platform by some senior surgeons to observe each other's techniques and pass critiques has been a new and growing phenomenon, however, this is still very informal, and no quality control exists in the virtual world.[22] It is possible that in the future, a crowd-sourced platform[23] to assess deidentified video-recorded skills could be one way to accomplish multiple evaluations for the same video. While the videos are deidentified prior to the assessment by attendings surgeons, the oral recitation component can potentially reveal the identity of a resident. This could be remedied by selecting the outside reviewers from a similar-sized institution to perform reciprocal evaluations of residents. Another big limitation of such a program is costs, both monetary and time, involved with the organization and implementation of this. While our study has funding through educational funds from within the department, this may not be feasible for all programs. While a longer testing interval may have been more beneficial in terms of studying knowledge or skill decay after the initial teaching dissections, in order to allow the whole process to be completed within one academic year, we found the 1-month mark after initial dissection teaching as an ideal time for testing.

Future Directions

For the foreseeable future, we intend to continue the preparatory dissection sessions using cadavers however, the eventual plan is to move the testing to the operating room to specifically increase the realism of actual dissection and to increase faculty involvement across the entire residency. In addition, we will include the use of standardized autonomy scales to measure the overall impact on operative autonomy in a more systematic manner for future years. Another aspect, we have considered is to utilize reviewers outside the program to potentially minimize resident recognition by voice and thus have completely blinded reviews of these recordings (Table 2).

CONCLUSION

This cadaver-based simulation curriculum has the potential to identify poor technical knowledge base as well as poor surgical techniques earlier in residency training allowing for focused practice and guidance. It also illustrates how the video assessment can form the foundation of an objective remediation pathway for residents. While the authors cannot definitively state that a curriculum like this increased trainee autonomy, it is a method that can provide faculty with objective data regarding resident technical skill. An ongoing structured technical assessment curriculum should be considered an integral component of surgical training. A future iteration of this type of curriculum may be a national, standardized, objective exam of surgical skills as a part of an in-training assessment.

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SUPPLEMENTARY INFORMATION

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jsurg.2019.08.004.