ISSN: 2576-2842

Research Article

Journal of Gynecology & Reproductive Medicine

An Effective, Low Cost, Do-it-Yourself Suture and Knot Tying Training Kit for the Novice Learner

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Submitted: 29 Nov 2018; **Accepted**: 04 Dec 2018; **Published**: 05 Jan 2019

Abstract

Introduction

Too Err is Human: Building a Safer Health System is a seminal report that highlights how improved training and objective assessment are key to reducing medical errors. The purpose of this study is to design a low cost, do-it-yourself (DIY) suture and knot tying training kit that enhances the novice learner's basic surgical skills and to evaluate the efficacy of this training kit.

Materials and Methods: *Pre-medical and medical students from the University of Hawaii were administered a pretest to evaluate their two-handed knot tying and simple interrupted suturing with instrument tie using an objective scoring system. Then, subjects were shown an instructional video and allowed to practice using a low-cost, DIY training kit. A posttest was administered in the same format as the pretest. The primary outcome was subject confidence level, and secondary outcomes were time and quality of suturing and knot tying.*

Results: *20 subjects were recruited. After using the training kit, mean confidence levels increased for two-handed knot tying (1.55 vs. 7.15, $p<0.0001$), suturing (1.75 vs. 6.95, $p<0.0001$), and instrument tie (1.50 vs. 6.95, $p<0.0001$). Mean time to complete two-handed knot tying (116.03 vs. 52.85 seconds, $p<0.0001$) and simple interrupted suturing with instrument tie (300.00 vs. 181.05 seconds, $p<0.0001$) both decreased. Mean quality of both knot tying (0 vs. 4.25, $p<0.0001$) and simple interrupted suturing with instrument tie (0 vs. 13.1, $p<0.0001$) increased.*

Conclusions: *This low-cost, DIY suture and knot tying training kit increased the confidence and basic surgical skills of the novice learner.*

Keywords: Medical Education, Patient Safety, Surgery

Abbreviations: DIY = do-it-yourself

Introduction

To Err is Human: Building a Safer Health System is a seminal report that highlights how improved training and objective assessment are key to reducing medical errors [1]. While physicians are often faulted when medical errors arise, it is important to recognize that some errors may stem from insufficient training during a physician's education. As such, the goal of any training system, including schools, should be to increase provider skill level in order to ultimately impact clinical outcomes. Enhanced training and assessment among pre-medical and medical students alike provides an approach to improving patient care, as early exposure to skills may better prepare them for duties they will have as future health care providers.

Implementing better training programs in education systems may help to reduce errors in medical fields that face the unique challenges that come with surgery. Every year, roughly 200 million patients undergo surgeries worldwide, yet the rate of medical errors remains inordinately high despite initiatives to enhance patient safety [2]. Learning proper suturing technique is paramount for patient safety, thus effective teaching of this skill is critical for reducing medical errors [3]. However, medical students do not typically receive extensive instruction in surgical techniques until they begin clerkships in their third and fourth years. Existing research states that delays in learning surgical techniques is detrimental, as relying on clerkships alone for sufficient training does not equip students appropriately for the demands and skills required of a surgeon [4]. These studies show that both the minimal availability of attending physicians to teach skills in depth along with the atmosphere of the operating room may contribute to the deficit in student education

[4]. The operating room is a stress-inducing setting for those who have had limited exposure, which may induce anxiety and poor self-confidence [4]. Ultimately, these factors can impair the training of students and even dissuade them from pursuing a career in a surgical field [4].

In contrast, current literature supports that training students early in their medical education using various modalities enhances skill levels and operating room performance [5]. Training systems range from live animal models to in-person workshops to virtual reality programs that each come with unique strengths and weakness. Proponents of the live animal models argue that it best simulates the real patient experience since the animal's viability poses the realistic goal of preserving life [4]. However, these models raise ethical challenges with regards to animal protection legislation thereby reducing their widespread availability to novice learners [4]. Other programs like peer-assisted workshops prove to be effective in educating students. In these programs, upper-level medical students teach younger students fundamental techniques like suturing and knot-tying. A 2015 study shows that providing multiple peer-assisted suture workshops significantly increases the mean number of completed sutures in comparison to baseline assessments. Self-reported ratings of dexterity, confidence, and interest in surgery also increased significantly amongst the junior medical students [5]. Another study investigating the effect of an intensive one-day training course yielded similar results: surgical skills improved significantly among the medical students post-training session [6].

While these workshops show improvements in surgical outcomes among medical students, they are not always feasible due to limited availability of senior medical students and physicians needed to lead the sessions. Virtual reality programs with supplemental training kits provide an alternative teaching method that could potentially overcome the challenge of requiring in-person educators. A recent study comparing the efficacy of conventional teaching (teacher lecture and demonstration followed by student practice) versus self-educational teaching with "surgeon's eye view" videos in teaching surgical skills shows that the latter training model was more enjoyable [7]. Additionally, skill levels were comparable between groups, suggesting there is no disadvantage to not receiving traditional instruction from an actual teacher [7]. Another study describes the benefits of video assisted learning in teaching laparoscopic surgical skills with a black box trainer kit [8]. Students assigned to learn laparoscopic techniques through a "step-by-step" instructional video performed better in knot-tying and knotting time in comparison to those who watched a video without having key steps highlighted [8]. Moreover, a randomized controlled trial shows that providing e-feedback to medical students after watching suture training videos is equally effective in improving proficiency of surgical skills when compared to providing standard verbal feedback [9].

The implementation of a suture training kit accompanied by virtual instructional videos could potentially aid with the mastery of surgical skills, and thus could reduce medical errors and improve patient outcomes. Ideal suturing kits should be inexpensive, portable, and re-usable. The purpose of this study is to design a low cost, do-it-yourself (DIY) suture and knot tying training kit that enhances the novice learner's basic surgical skills and to evaluate the efficacy of this training kit. To the best of our knowledge, this is the first ever study to develop and assess an affordable and easily accessible self-directed training kit for improving suturing and knot tying skills.

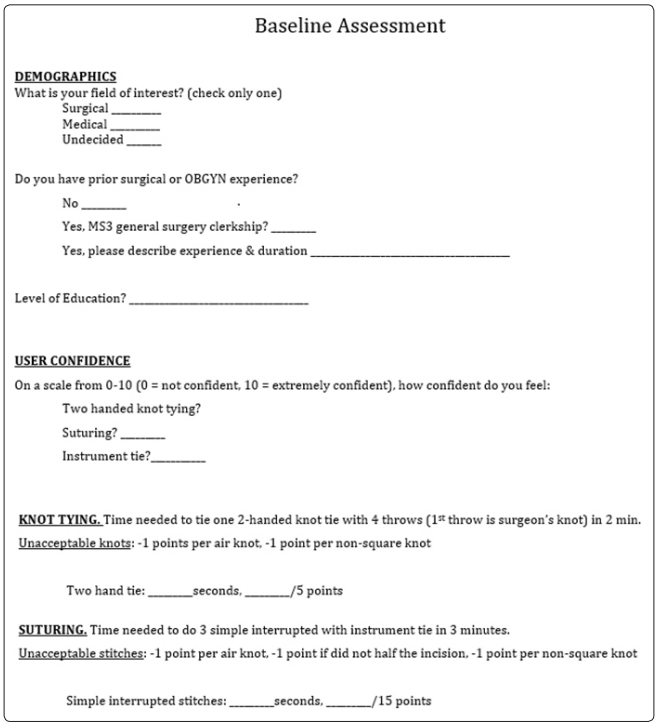
Methods

The Study Design

This prospective pretest-posttest cohort study was conducted in March 2018. Study exemption from an ethics review committee was obtained from the Hawaii Pacific Health Institutional Review Board. Inclusion criteria included pre-medical undergraduate students along with first- and second-year medical students from the University of Hawaii.

A pretest was administered to measure the time required to complete two-handed knot tying and simple interrupted suture with instrument tie, in addition to assessing the quality of aforementioned tasks with a 5-point and 15-point scoring system, respectively (Figure 1). Subjects had the option to opt out of the pretest, and if they opted out, they were assigned the maximum time allotted for knot tying (120 seconds) and suturing (300 seconds) and 0 points for both quality assessments. Self-reported confidence level performing such tasks was also recorded on a 0-10 scale. After a baseline evaluation of skill and confidence levels, a video demonstrating the knot tying and suture tying techniques was shown to the participants. Subjects were allowed 80 minutes to practice their two-handed knot tying and simple interrupted suturing using a low-cost, DIY suture training kit. The duration of time spent practicing each skill was recorded by the subject. A posttest was administered in the same format as the pre-test, and self-reported confidence level was reassessed (Figure 2). The primary outcome was confidence level. Secondary outcomes included quality and timing of the two-handed knot tying and simple interrupted with instrument tie techniques.

Data were analyzed using paired t-test or Wilcox signed rank test to compare between pretest and posttest measures. Pearson or Spearman correlation statistics were used to assess association between knot tying or suturing time and subject practice time between the pretest and posttest for each technique. Statistical differences were considered significant for p-values less than 0.05.



Baseline Assessment

DEMOGRAPHICS

What is your field of interest? (check only one)

Surgical _____
Medical _____
Undecided _____

Do you have prior surgical or OBGYN experience?

No _____
Yes, MS3 general surgery clerkship? _____
Yes, please describe experience & duration _____

Level of Education? _____

USER CONFIDENCE

On a scale from 0-10 (0 = not confident, 10 = extremely confident), how confident do you feel:

Two handed knot tying?
Suturing? _____
Instrument tie?_____

KNOT TYING. Time needed to tie one 2-handed knot tie with 4 throws (1st throw is surgeon's knot) in 2 min.
Unacceptable knots: -1 points per air knot, -1 point per non-square knot

Two hand tie: _____seconds, _____/5 points

SUTURING. Time needed to do 3 simple interrupted with instrument tie in 3 minutes.
Unacceptable stitches: -1 point per air knot, -1 point if did not half the incision, -1 point per non-square knot

Simple interrupted stitches: _____seconds, _____/15 points

Figure 1: Pretest and posttest scoring system

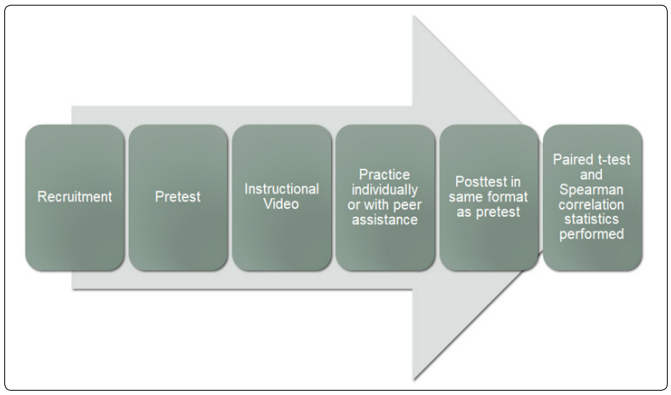


Figure 2: Study design

The Training Kit

The training kit was constructed from a 10 x 20 cm wooden box (Figure 3). Four equidistance holes were drilled into the edges of the box and used to anchor a stretched latex glove to the box. The glove was used to mimic tissue, and an eclipse was drawn on the glove to mimic an incision. The training kit also included a needle holder, tissue forceps, scissors, suture needles, and monofilament wire. The monofilament wire was used to practice two-handed knot tying. One training kit cost $12.35 to construct (Table 1).

Figure 3: A low-cost, do-it-yourself suture training kit

Table 1: Cost to assemble a suture training kit

Item	Supplier	Cost
Wooden box	Darico	$4.00
Needle holder	Allheart	$2.39
Tissue forceps	Allheart	$1.70
Scissors	Allheart	$0.70
Suture needle	Fine Science Tools	$2.00
Monofilament wire	Amazon	$1.56
	TOTAL	$12.35

The Instructional Video

A 4.5-minute step-by-step instructional video was created to explain and demonstrate how to perform a two-handed knot, instrument tie, and simple interrupted stitch. This video is freely available online to the public at https://youtu.be/05itRB3mGLQ.

Results

The study recruited 14 pre-medical undergraduate students and 6 second-year medical students, all with no or limited experience in basic surgical skills. Of the 20 subjects, 17 opted out of the pretest assessment. After practicing with the training kit, the mean confidence levels increased for the two-handed knot tying (1.55 vs. 7.15, paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0002$), suturing (1.75 vs. 6.95, paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0001$) and instrument tie (1.50 vs. 6.95, paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0001$) (Figure 4). The mean time to complete two-handed knot tying (116.03 vs. 52.85 seconds, paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0002$) and simple interrupted suturing with instrument tie (300.00 vs. 181.05 seconds, paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0001$) both decreased (Figure 5). The mean quality of both knot tying (0 vs. 4.25, paired t-test $p<0.0001$, Wilcox signed rank test $p<0.0001$) and simple interrupted suturing with instrument tie (0 vs. 13.1, paired t-test $p<0.0001$, Wilcox signed rank test $p<0.0001$) increased (Figure 6).

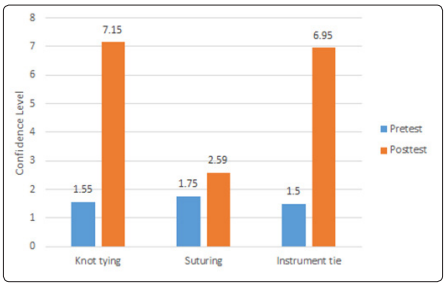


Figure 4: Confidence levels in knot tying, suturing, and instrument tie (10 point scale) – pretest and posttest (paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0001$)

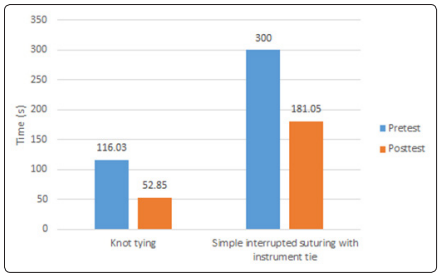


Figure 5: Time to complete knot tying and simple interrupted suturing with instrument tie – pretest and posttest (paired t-test $p<0.0001$, Wilcox signed rank test $p=0.0002$)

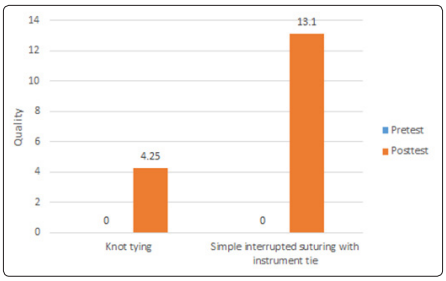


Figure 6: Quality of knot tying (5 point scale) and simple interrupted suturing with instrument tie (15 point scale) – pretest and posttest (paired t-test $p<0.0001$, Wilcox signed rank test $p<0.0001$)

When allowed 80 minutes to practice, the duration of time each subject spent practicing knot tying ranged from 15 to 40 minutes (mean 25.6 minutes) and simple interrupted suturing ranged from 15 to 50 minutes (mean 27.0 minutes). Subject practice time between the pretest and posttest for each technique did not show a significant correlation with either the knot tying (Spearman p=0.83, Pearson p=0.47) or suturing results (Spearman p=0.29, Pearson p=0.41).

Discussion

Suturing and knot tying are essential components of surgery, and thus should necessitate training early in medical education. Like previous studies this study showed increased proficiency in surgical skills after implementation of a training system [3-8]. The time needed to perform knot tying and suturing decreased by more than half, and the quality of the aforementioned skills increased from zero to an almost perfect score. Unlike most of the other studies, strength of this study was that it also assessed subject confidence, which increased nearly five-fold after using the training kit. Confidence is essential during the learning period because it can strongly influence learner attitude and future training. Without adequate training before clerkships, students can suffer from low self-confidence and anxiety, potentially leading to impaired operating room performance and deterrence from pursuing surgical careers.

Conventional methods for suture practice include using animal models, participating in peer-assisted or expert-led workshops, and operating elaborate suturing kits. However, these programs are not always feasible due to ethical or availability constraints of medical professionals, which lead to suboptimal exposure to surgical techniques prior to training on human patients. A reform in suture training is needed to improve access to surgical training, which was the driving inspiration for our training kit. This unique training kit was designed to be easily accessible via affordability and reusability. One training kit cost $12.35 to construct, but modifications could decrease costs even further. For example, a sturdy cardboard box could replace the wooden box and household scissors would suffice for cutting suture. Moreover, the training kit's accompanying instructional video facilitates self-directed learning. By promoting independent learning, the video can decrease the learner's reliance on experienced surgical personnel, such as resident and attending physicians who are often strained for time. The instructional video is available on the internet for public use at no cost.

A limitation to this study is sample size. Since this was a pilot study, a sample size of convenience was employed. In the future, a larger sample size with equal representation among pre-medical students, first-year medical students, and second-year medical students should be obtained. Another drawback is a lack of pretest data, since 17 participants decided to opt out of the pretest assessment. Without significant participation in the pretest portion of the study, it is difficult to determine a reliable baseline of student skill level. Pretest participation should also be encouraged, as it provides baseline information that is useful for comparison.

Future directions include follow up assessments to demonstrate the long term impact of the training kit and creating additional videos for one-handed knot tying and other suturing techniques, like running stitches or figure-of-eight stitches. Integration of this training kit into the medical school curriculum would strongly benefit students, especially during the preclinical years.

In conclusion, this study demonstrates that a low cost, DIY suture and knot tying training kit supplemented by an instructional video can significantly increase the novice learner's confidence and skill levels. To the best of our knowledge, this is the first ever study to develop and assess an affordable and easily accessible self-directed training kit for suturing and knot tying. This training kit may better prepare students for clinical experiences allowing them to potentially utilize these basic skills intra-operatively during their short clinical clerkships, which could ultimately lead to significant improvements in patient safety.

Acknowledgements

We would like to thank the Department of Obstetrics, Gynecology and Women's Health at the University of Hawaii for their financial support and dedication to medical education. Also, many thanks to Christina Buchanan, MD and Aiwa Ono, BS for taking the time to help run this project.

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