BASIC SKILLS TRAINING FOR ROBOTIC CONSOLE SURGEON MODULE

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OVERVIEW

This module is designed to teach basic robotic surgical skills. This comprehensive proficiency-based curriculum consists of 3 standardized components: 1) online didactic video-based tutorial, 2) half-day hands-on interactive and pre-test session, and 3) self-training on 9-inanimate exercises. This curriculum was developed to teach surgical trainees in the acquisition of basic robotic surgical skills through a simulation-based training model. This curriculum is designed for mid-level to senior residents, but may also be quite useful for fellows and attending surgeons with minimal to no robotic surgical experience. These tasks may also be used for more novice learners, but may require some modifications regarding proficiency levels. Since this curriculum contains content that is independent of specific procedures, it may be useful for various specialties including: surgery, gynecology, and urology.

I. OBJECTIVES

By the end of this training curriculum participants should be able to:

1) Understand basic principles regarding use of the robotic surgical system (da Vinci platform).
2) Perform a variety of basic robotic surgical skills including: robotic instrument maneuvering and manipulation, transferring objects between instruments, holding and grasping, cutting, wrist articulation, console operation (pedal operation, clutching, 4^{th} arm activation, etc.), simple interrupted and continuous running suturing, and camera driving (movement, adjustment, and focusing).
3) Perform key aspects of operative planning for robotic procedures.
4) Perform setup procedures for robotic system components.

II. ASSUMPTIONS

It is assumed that the participant will have had minimal, if any, prior robotic surgical skills training or experience.

III. SUGGESTED READINGS

1) Dulan G, Hogg DC, Gilberg-Fisher K, Rege RV, Arain NA, Tesfay ST, Scott DJ. Developing a comprehensive, proficiency-based training program for robotic surgery. Surgery 2012 (in press).
2) Dulan G, Rege RV, Hogg DC, Gilberg-Fisher KK, Tesfay ST, Scott DJ. Content and face validity of a comprehensive robotic skills training program for general surgery, urology, and gynecology. Am J Surg 2012;203:535-9.
3) Dulan G, Rege RV, Hogg DC, Gilberg-Fisher KM, Arain NA, Tesfay ST, Scott DJ. Proficiency-based training for robotic surgery: construct validity, workload,

and expert levels for nine inanimate exercises. Surg Endosc 2012;26:1516-21.
4) Arain NA, Dulan G, Hogg DC, Rege RV, Powers CE, Tesfay ST, Hynan LS, Scott DJ. Comprehensive proficiency-based inanimate training for robotic surgery: reliability, feasibility, and educational benefit. Surg Endosc 2012 (in press: DOI 10.1007/s00464-012-2264-x).
5) Online robotic surgical skills tutorial video: http://www.utsouthwestern.edu/education/medical-school/departments/surgery/minimally-invasive-surgery/simulationtraining-laboratory.html
6) Online didactic and video-based self-assessment module: www.davincisurgerycommunity.com

IV. DESCRIPTION OF LABORATORY MODULE

This curriculum consists of 3 standardized components: 1) online didactic video-based tutorial, 2) half-day hands-on interactive and pre-test (baseline performance) session, and 3) self-training on 9-inanimate exercises (self-practice to expert-derived and previously validated proficiency levels) and post-test (final performance). Trainees are divided into multiple groups (consisting of 5-6 trainees) for each half-day interactive and pre-test session, and given 2 months to complete the curriculum.

Trainees are required to view the online didactic tutorial (www.davincisurgerycommunity.com) and successfully complete a 33-40 multiple-choice question self-assessment exam prior to attending the orientation and pre-test session. This tutorial demonstrates basic robotic setup, docking, instrumentation, port layout and configuration, and console specifications, features, and operation. After passing the online self-assessment exam, trainees are provided with a certificate of completion which serves as an “admission ticket” to the orientation session.

A standardized half-day hands-on interactive and pre-testing session is provided for each learner group. This 4-hour session is divided into two 2-hour parts. During the first 2-hours, a full-time dedicated robotic skills instructor (who also serves as a proctor) provides a brief introduction and background presentation on robotic surgery. Additionally, the instructor provides a hands-on demonstration of appropriate setup and usage of all system components. Each learner is then required to demonstrate proficiency in the areas of port placement, docking (bedside cart placement, arm positioning, instrument insertion), and console usage. Using a global assessment checklist survey, trainees are checked-off after successfully performing these various exercises. During the last 2-hours, an orientation to the 9-inanimate exercises, models, and scoring system (based on previously validated metrics on time and errors) is conducted. A 42-minute video demonstrating the proper technique for task performance and error avoidance strategies is also shown. Trainees then perform a one-on-one proctored

repetition of each of the 9 tasks (pre-test) to establish a baseline assessment of performance level.

The orientation and pre-test session is then followed by a 2-month self-training period on the 9-inanimate exercises. Five of these tasks were based on exercises from the Fundamentals of Laparoscopic Surgery (FLS) program (http://www.flsprogram.org), either with or without modifications. The remaining 4 tasks were developed in our laboratory. Studies we have conducted support content, face, and construct validity, acceptable reliability measures, and suitable feasibility and benefit. While other tasks and curricula may exist, we are most comfortable with the tasks described in this module given the level of validation available. All 9 of our exercises use an FLS laparoscopic box trainer; similar box trainers may be suitable. During the 2-month self-training interval, learners are required to train to previously validated and expert-derived proficiency-based levels. Training sessions are individually scheduled between the trainee and proctor. The proctor scores each repetition (time and errors) for each of the 9 tasks and provides guidance and feedback as needed. Trainees are required to reach proficiency-based levels (or a maximum number of 80 repetitions) on each of the 9 tasks before successfully completing the training period. All tasks are to be practiced in order, beginning with Task 1 and ending with Task 9. Trainees must reach proficiency on each task before proceeding to the next one, as the tasks build in complexity and foster stepwise acquisition of skills. Proficiency is defined as 2 consecutive repetitions (at or above proficiency levels) for each task with no errors. Once proficiency (or the maximum number of 80 repetitions on a task) has been achieved, each trainee will then schedule a one-on-one post-test session with the proctor.

The post-test session consists of performing 1 proctored repetition of each task (in order; Tasks 1-9) without any warm-up. Trainees are not required to reach proficiency levels during the post-test, however, it is expected that trainees will perform within 80% of the proficiency level. If this is not reached, remediation and additional training is usually proscribed. Trainees are then awarded a certificate documenting their successful completion of this comprehensive proficiency-based robotic training curriculum.

The 9-inanimate exercises used in this curriculum are designed to teach basic robotic surgical skills including: instrument handling, suturing (simple interrupted and running), knot-tying (surgeon's and square knots), camera driving and navigation, and clutching. All of these exercises use inexpensive and easily replaceable commercially available models.

In our training laboratory, we have a Standard da Vinci system. Our system is equipped with a 4th arm and uses 8mm instruments. This curriculum has been specifically designed around this system. The inanimate tasks are sufficiently generic that they may be readily used with an "S" or "SI" unit. Since we use the Standard system, we require all participants to complete the online didactic

video-based tutorial (www.davincisurgerycommunity.com) for this system. Depending on the system participants will use in the clinical setting, they are also required to complete either the “S” or “SI” tutorial.

It is optional to have a dedicated system in a laboratory setting for training purposes. This setup eliminates competition for resources (especially time for training) as may be the case with training conducted using systems in clinical operating rooms. However, this curriculum may be used in the OR environment if time is available.

Robotic surgeon console (Standard system)

da Vinci robotic surgical system used for training

8mm robotic surgical instruments used for training on 9-inanimate exercises (L to R: needle drivers (x2), scissors, Maryland grasper, and Prograsp™)

The curriculum consists of 9 tasks:

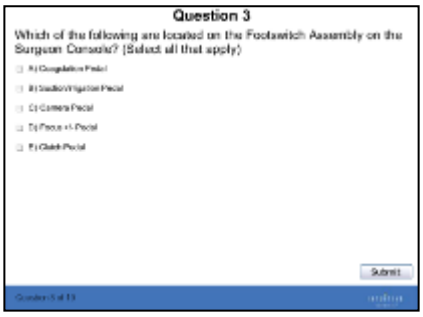
1) *Peg Transfer
2) Clutch and Camera Movement
3) Rubber Band Transfer
4) *Suture (Simple Interrupted)
5) *Clutch and Camera Peg Transfer
6) Stair Rubber Band Transfer

7) Running and Cutting Rubber Band
8) *Pattern Cut
9) *Suture (Running)

*FLS-derived tasks; all other tasks were newly developed.

V. DESCRIPTION OF TECHNIQUES AND PROCEDURE

A. Part-I: Online Didactic Video-based Tutorial



1. Trainees must create and register for a new account by going to the following website: www.davincisurgerycommunity.com.
2. All trainees must enroll for the Standard system training; S or SI tutorial modules are assigned to trainees using these systems in the clinical setting.
3. After registering and selecting the appropriate training module, trainees then begin the 1-hour online video-based modules.
4. Trainees then complete a 33-40 multiple-choice question self-assessment exam.
5. Trainees must print and bring the certificate of completion with them to the half-day hands-on interactive session.
6. Confirmation of completion of the online didactic video-based tutorial and self-assessment exam is documented by a proctor.

B. Part-II: Half-day Hands-on Interactive and Pre-test Session

1) After verifying completion of pre-course materials, trainees then participate in the half-day hands-on interactive session.
2) Using a global assessment checklist survey (“needs more practice”, “meets expectations”, or “exceeds expectations”), trainees are checked

off after demonstrating proficiency on each of the following exercises:

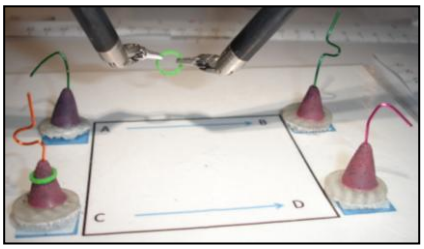
a. Port placement
   i. Appropriate distance of camera port placement from target anatomy.
   ii. Proper distance between instrument arms and camera port.
   iii. Optimal triangulation; cone of 60-degrees.
b. Docking
   i. Bedside cart placement
      1. Appropriate positioning without encountering any obstacles (OR table, patient, etc.).
   ii. Arm positioning
      1. Proper camera arm placement relative to the 4th arm.
      2. Optimal positioning of the camera arm ensuring alignment of the camera cannula, target anatomy, and surgical cart.
      3. Proper positioning of the 4th arm relative to the floor.
   iii. Instrument insertion
   iv. Equipment preparation
   v. Proper placement of sterile adapter and instrument insertion.
   vi. Proper guided tool exchange.
c. Console usage
   i. Activation of the system ("ready" button)
   ii. Use of clutch
   iii. Use of camera

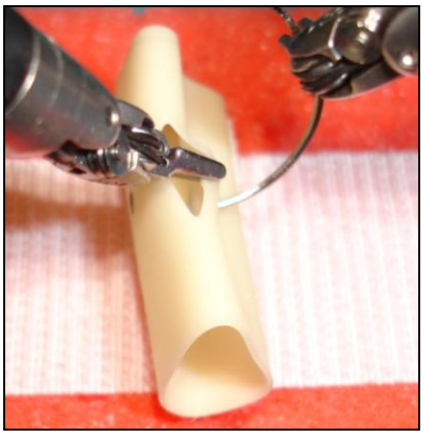
3) An orientation to the 9-inanimate exercises, models, and scoring system is then conducted and a 42-

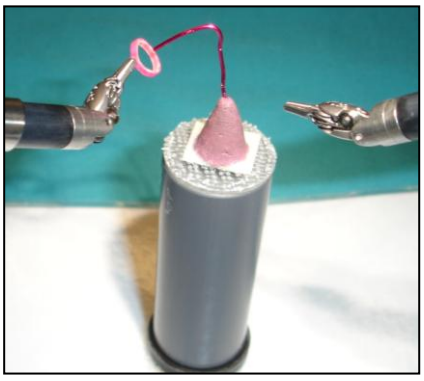
minute video tutorial demonstrating the proper technique for task performance and error avoidance strategies is shown.

4) Trainees then perform a one-on-one proctored repetition of each of the 9 tasks (pre-test) to establish a baseline assessment of performance level.

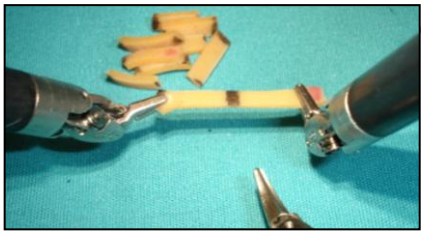
C. Part-III: Self-Training on 9-inanimate Exercises







1) Learners then begin the training component of this comprehensive proficiency-based curriculum.
2) During the 2-month self-training period, trainees are required to train to previously validated and expert-derived proficiency-based levels.
3) Training sessions are individually scheduled between the trainee and proctor.
4) The proctor scores each repetition (based on completion time and errors) for each of the 9 tasks and provides guidance and feedback as needed.
5) Trainees are required to reach proficiency-based levels (or a maximum number of 80 repetitions) on each of the 9 tasks before successfully completing the training period.
6) All tasks are to be practiced in order, beginning with Task 1 and ending with Task 9. Trainees must reach proficiency on each task before proceeding to the next one.
7) Proficiency is defined as 2 consecutive repetitions (at or above proficiency levels) for each task with no errors.
8) Once proficiency (or the maximum number of 80 repetitions on a task) has been achieved, each trainee will then schedule a one-on-one post-test session with the proctor. The post-test will be used to assess final performance.



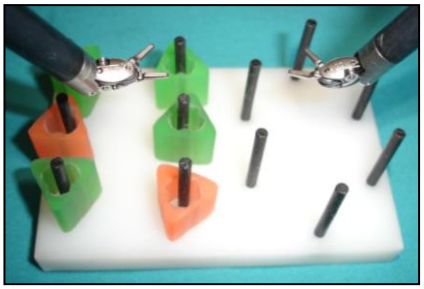
9) During the post-test, the trainee must perform 1-proctored repetition on each of the 9 tasks. It is not required that the trainee reach proficiency levels; however, performance within 80% of proficiency is expected. If this does not occur, remediation and additional training is usually proscribed.

D. Zeroing Instruments (Neutral Positioning)

1) Prior to beginning each task, the instruments must be “zeroed” so that maximal reach and optimal performance are afforded. This process must be repeated at the beginning of each exercise.
2) This procedure is detailed and demonstrated in the video tutorial.

3) After being seated at the robotic console, the trainee 1st presses (and holds) the clutch pedal and brings both instruments inward (medially) and towards the arm rest.
4) The joysticks are then brought in together so as to make contact with one another.
5) The trainee then moves both joysticks about 1-2 inches away from the arm rest, 1-2 inches outward (laterally), and finally 1-2 inches downward (vertically).
6) Both arms must be in a comfortable and relaxed position on the forearm support bar so as to ensure optimal performance of each task with maximal ergonomics and minimal exertion.

E. Task 1: Peg Transfer



1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS

laparoscopic box trainer, left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (inactive), FLS pegboard (securely placed within the box trainer using Velcro), 6 rubber pegs, and stopwatch.

2) This task uses the peg transfer task from the FLS program with no modifications.

3) Before beginning the task, the instruments must be "zeroed" as previously described.

4) The pegboard is centered in the camera's field of view. The 6 rubber pegs are placed on the left side of the pegboard.

5) This task requires the trainee to transfer 6 rubber pegs from the left side of the pegboard to the right (and vice versa). "Mid-air" transferring of the pegs from one needle driver to the other must be performed in both directions.

6) The trainee first grasps the rubber peg with the left needle driver, picks it up, and transfers it to the right needle driver.

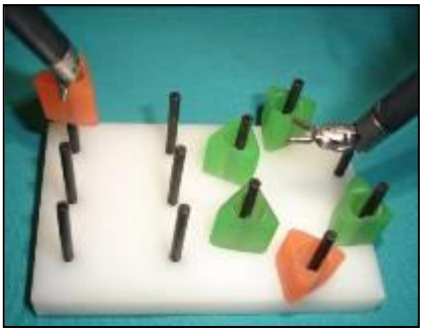
7) The right needle driver is then used to place the peg on the right side of the peg board.

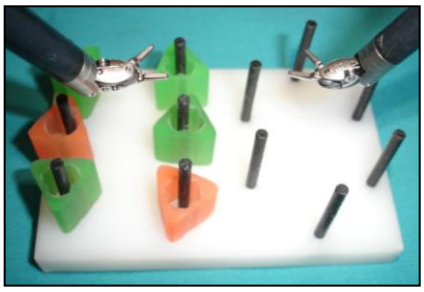
8) This is repeated until all 6 pegs have been transferred and placed on the right side.

9) In a similar manner, the trainee then transfers each of the 6 pegs back to the left side ensuring that each peg is transferred from the right needle driver to the left.

10) Care must be taken not to drop the pegs (outside of the field of view) or failing to transfer the pegs between instruments.

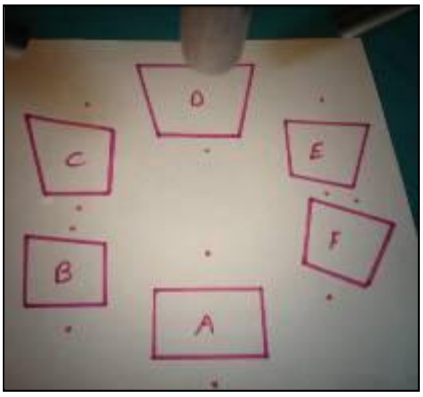
11) Clutching is allowed (if needed), but is not required. The camera must remain fixed during the performance of this task. Articulation is





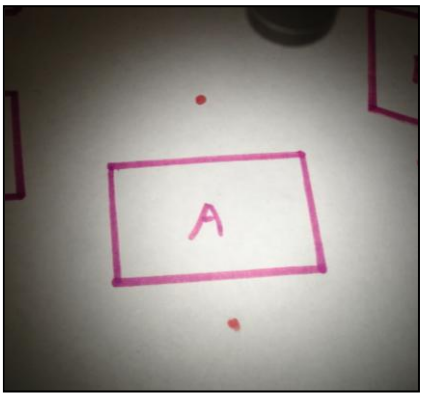
encouraged and may faciliate the placement and transferring of pegs.

12) Time starts when the 1st rubber peg is grasped by the left needle driver; time stops when the final rubber peg has been placed by the left needle driver.
13) Scoring formula: Score = 300 – time – 10 (sum of errors)
14) Cutoff/maximum time allotted = 300 seconds
15) Proficiency Score: 234 (66 seconds; no errors)

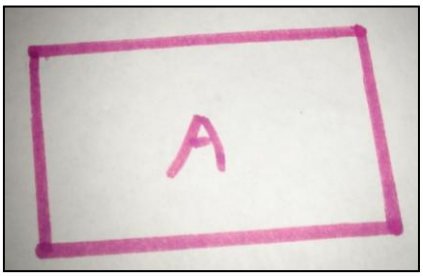


F. Task 2: Clutch and Camera Movement

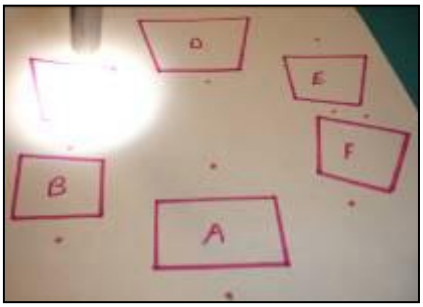
1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, left hand (no instrument), right hand (no instrument), 0º camera, 4th arm (inactive), custom-made template, and stopwatch.
2) This task uses a custom-made template with 6 four-sided geometric shapes arranged in a clockwise manner (labeled from “A” to “F”). Red dots are placed above and below each shape representing errors.

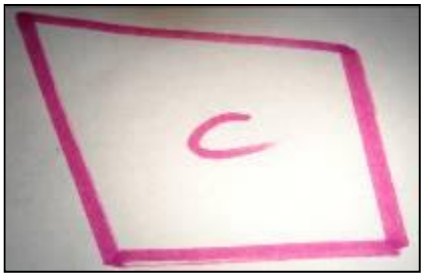


3) This task requires the trainee to move and navigate the camera (in a clockwise manner beginning and ending with shape “A”) while zooming in on each geometric shape so that the 2 error red dots (located above and below each shape) are not visible but the entire shape is. The trainee must verbally confirm with the proctor when they have determined they have acquired the shape. Clutching and camera movement are required to perform this task.

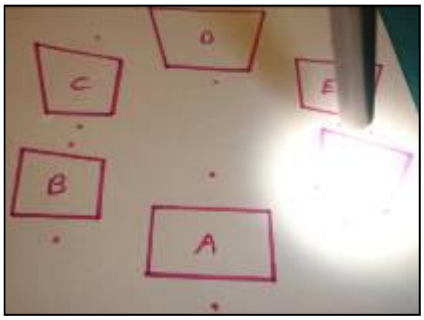


4) The trainee first clutches and moves the camera to the first shape (labeled “A”) and brings the shape



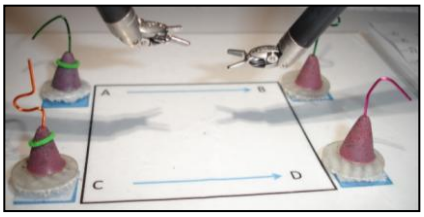


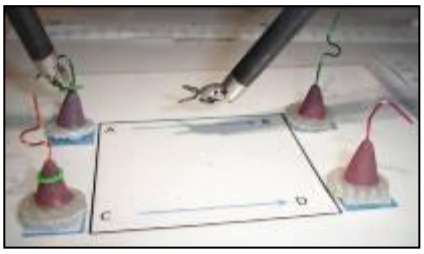
into focus. Once the 2 red error dots are no longer visible by the trainee, a verbal confirmation is communicated to the proctor and the trainee then moves on to the next shape.

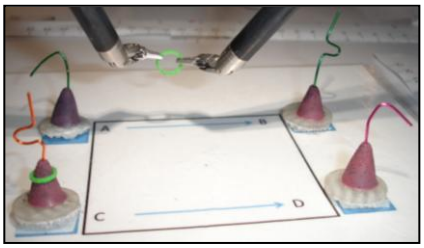


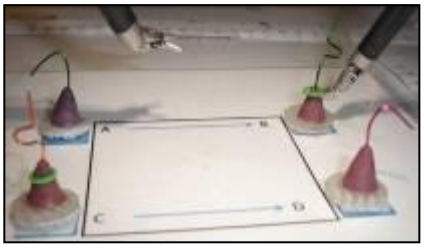
5) This process is repeated and the task is completed when the trainee returns to shape “A”.
6) Time starts when the trainee first moves the camera to “A”; time stops when the trainee completes the clockwise rotation and returns to “A”.
7) Scoring formula: Score = 300 – time – 10 (sum of errors)
8) Cutoff/maximum time allotted = 300 seconds
9) Proficiency Score: 248 (52 seconds; no errors)

G. Task 3: Rubber Band Transfer





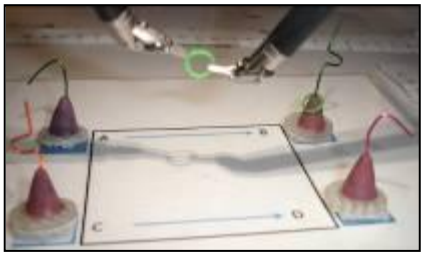




1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (inactive), custom-made template using commercially available models (with curved posts) and 2 rubber bands (The Chamberlain Group, Great Barrington, MA), and stopwatch.
2) This task uses a custom-designed template using curved wire posts and rubber bands that are commercially available. The rubber bands measure 7mm in diameter. The 4 models should be affixed to each corner using Velcro and labeled in the following manner: the upper pair of models labeled “A’ and “B”, and the lower pair of models “C” and “D”. The distance between the targets is 7.5cm and the square template measures 7.5cm by 7cm.
3) Before beginning the task, the instruments must be “zeroed”.

4) The trainee must grasp the rubber band placed at the base of the copper wire model with the left needle driver, transfer it to the right needle driver, and place it on the model on the right side. This task must be performed in a left-to-right direction from “A” to “B” and “C” to “D”, then reversed from a right-to-left direction from “D” to “C” and “B” to “A”.

5) The trainee first grasps the rubber band with the left needle driver located at position “A”, and then carefully articulates the needle driver around the thin colored wire taking care not to avulse the model.



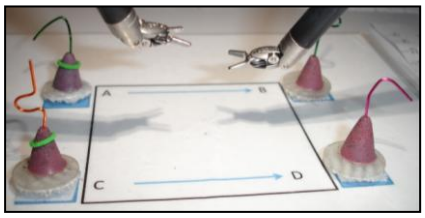
6) The rubber band is then transferred mid-air to the right needle driver, and placed at the base of the model at position “B”.

7) The trainee then grasps the rubber band located at position “C” with the left needle driver, transfers it to the right needle driver, and then places it at the base of the model at position “D”.

8) After the right needle driver is released and the rubber band has been placed at the base of the model at position “D”, the right needle driver is then used to re-grasp the rubber band, transfer it to the left needle driver, and place it at the base of the model at position “C”.

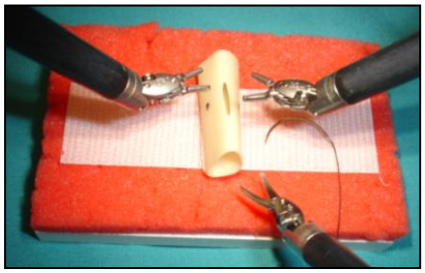
9) Attention is then redirected to the rubber band at position “B”, and the process is repeated.

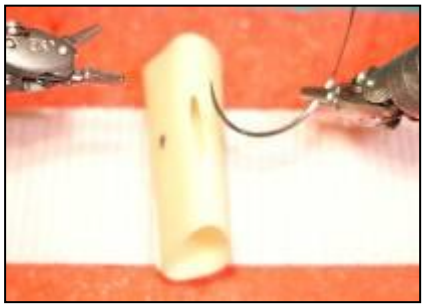
10) Time starts when the 1st rubber band is grasped by the left needle driver; time stops when the final rubber band has been placed at “C” by the left needle driver.

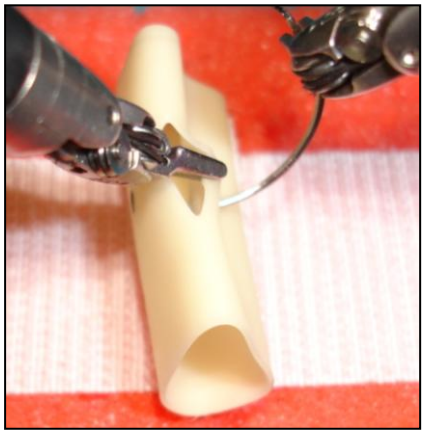


11) Care must be taken to avoid dropping the rubber bands outside of the field of view or avulsing the models.
12) Clutching is allowed (if needed), but is not required. The camera must remain fixed during the performance of this task.
13) Scoring formula: Score = 300 – time – 10 (sum of errors)
14) Cutoff/maximum time allotted = 300 seconds
15) Proficiency Score: 229 (75 seconds; no errors)

H. Task 4: Suture (Simple Interrupted)







1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, foam suturing board (centered in the box trainer and secured using Velcro), Penrose drain (FLS suturing model) with 2 pre-inked targets and firmly affixed to the foam suturing board with Velcro, 2-0 silk suture on a tapered needle (12cm length), left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (scissors), and stopwatch.
2) This task uses the Penrose drain suturing model from the FLS program (Task 5: Intracorporeal Suturing) with no modifications.
3) Before beginning the task, the instruments must be “zeroed”.
4) The trainee must perform a simple interrupted suture (3 knots total) by approximating a simulated incision within the FLS suturing model.
5) The trainee first grasps the needle with the left needle driver, and carefully positions it within the right needle driver in a forward position. Alternatively, the needle may be grasped with the right needle driver and gently positioned using the left needle driver. Care must be taken to

avoid bending or damaging the needle.

6) The left needle driver is then used to grasp and manipulate the front (or within the incision) of the suturing model while passing the needle through the 1st inked target with the right needle driver.

7) The needle is then passed through the 2nd inked target using a “single-bite” technique.

8) The needle is then pulled completely through the suturing model with either needle driver leaving a short suture tail for subsequent knot-tying.

9) The suture is then grasped with the right needle driver, and 2 loops are wrapped around the tip of the left needle driver. Alternatively, the needle (as opposed to the suture) may be grasped to form the loops.

10) The left needle driver is used to pull through the suture tail and tied securely in place completing the surgeon’s knot. Care must be taken to avoid excessive force while placing and tying the knot.

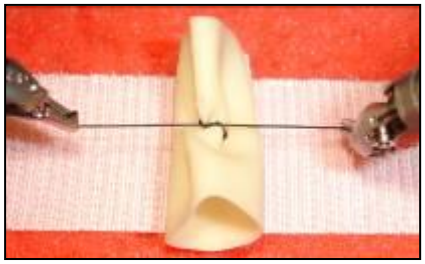
11) Using the FLS protocol for laparoscopic suturing and knot-tying (i.e. alternating hands), the left needle driver is then used to perform a single loop around the tip of the right needle driver.

12) The suture tail is then grasped and pulled through this loop, thereby completing a square knot.

13) Alternating hands once more, this process is repeated, and the final square knot is tied.

14) The trainee then activates the 4th arm (scissors) by quickly tapping the clutch pedal, and cuts both suture tails to 1cm in length. Alternatively, both strands may be placed within



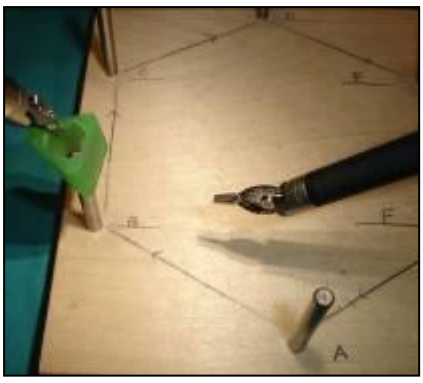

the left needle driver, and a single cut may be performed.

15) Care must be taken to avoid excessive manipulation and handling of the suture (so as not to fray, damage, or break it), suturing model (avulsion), and needle (separation/breakage).

16) Time starts when the needle is first grasped; time stops when the final suture tails have been cut to 1cm in length.
17) Scoring formula: Score = 600 – time – 10 (sum of errors)
18) Cutoff/maximum time allotted = 600 seconds
19) Proficiency Score: 509 (91 seconds; no errors)

I. Task 5: Clutch and Camera Peg Transfer

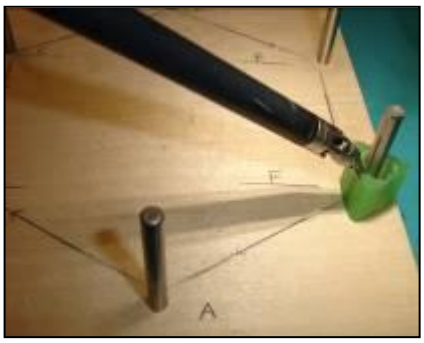
1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (inactive), custom-designed wooden peg board with metal posts marked “A” through “F”, and stopwatch.



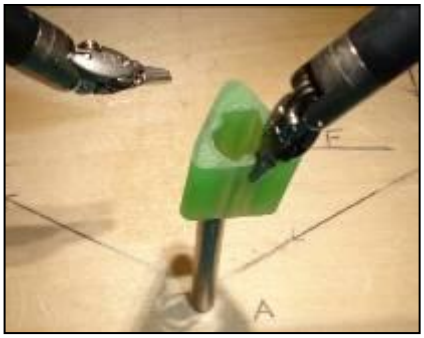
2) This task uses a custom-designed wooden board with 6 metal posts (3.5cm high) inserted within it and arranged in a clockwise manner and labeled “A” to “F” on a hexagonal pattern. The distance between each metal post is 7cm. A single rubber peg (used in Task 1) is placed at position “A”.

3) This task requires the trainee to grasp the rubber peg at position “A” and place it at position “B” moving in a clockwise manner while alternating hands between each placement. Clutching and camera movement are required to complete this task. Care must be taken not to

drop the peg outside of the field of view.

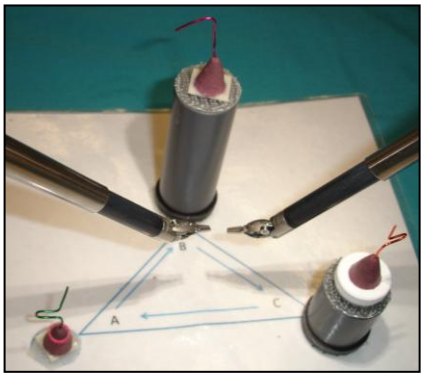


4) The trainee first clutches and moves the camera to position “A” and picks up the peg with the left needle driver.
5) The trainee then transfers and places the peg at position “B” (clutching and moving the camera as needed).

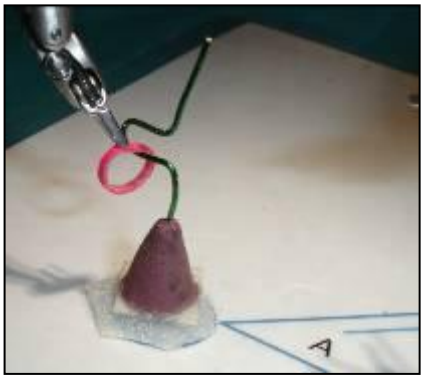


6) Using the right needle driver, the trainee then picks up the peg and transfers it to the next position.
7) This process is repeated and the task is completed when the trainee returns the peg to position “A”.
8) Time starts when the trainee first grasps the peg at position “A”; time stops when the trainee completes the clockwise rotation and returns the peg back to position “A”.
9) Scoring formula: Score = 300 – time – 10 (sum of errors)
10) Cutoff/maximum time allotted = 300 seconds
11) Proficiency Score: 251 (49 seconds; no errors)

J. Task 6: Stair Rubber Band Transfer



1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (inactive), custom-made template using commercially available models (with curved posts) and a single rubber band (The Chamberlain Group, Great Barrington, MA), and stopwatch.



2) This task uses a custom-designed template using 3 models (of varying heights) which are affixed (using Velcro) at each of the 3 vertices of the triangle. The vertices are labeled from “A” to “C” and measure 8cm between each target. At position “A” the model is directly affixed (to the

laminated sheet) with Velcro; the 14cm tall model is placed at position “B” and the 7cm tall model at position “C”. A single rubber band (used in Task 3) is placed at position “A”.

3) Before beginning the task, the instruments must be “zeroed” and the camera centered.

4) The trainee must grasp the rubber band placed at the base of the copper wire model (at position “A”) with the left needle driver and transfer it to position “B”. The right needle driver is then used to grasp the rubber band and place it at the next target (position “C”). The task is completed when the trainee has placed the rubber band back at position “A” with the left needle driver. Clutching and camera movement are required to perform this task.

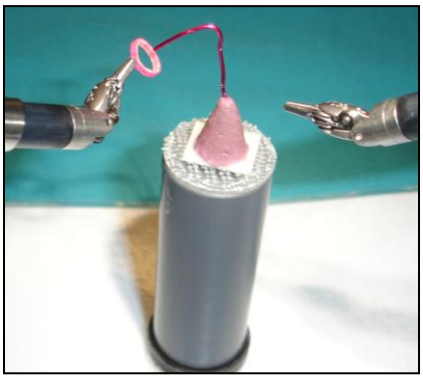
5) The trainee first moves the camera to position “A” and grasps the rubber band with the left needle driver making sure to articulate around the thin colored wire as needed. Care must be taken not to avulse the model.

6) The rubber band is then transferred to position “B” and placed at the base of the model. When moving from position “A” to “B”, camera movement is required (as position “B” is a higher model than “A”).

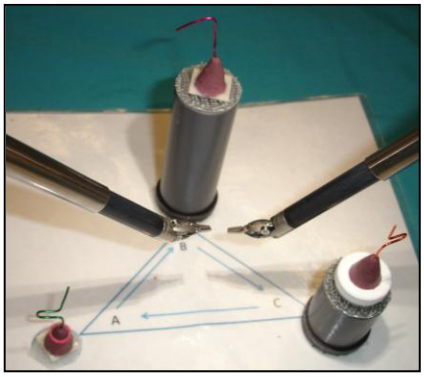
7) The trainee then grasps the rubber band at position “B” with the right needle driver and places it at position “C”.

8) This process is repeated an additional time, and the task is completed when the trainee places the rubber band back at position “A” with the left needle driver.

9) Time starts when the trainee first

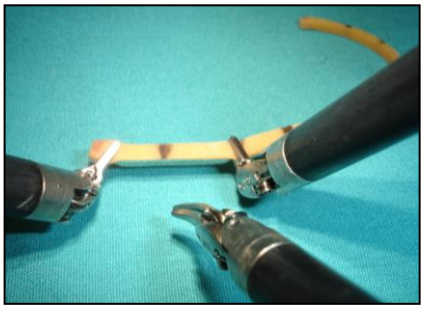


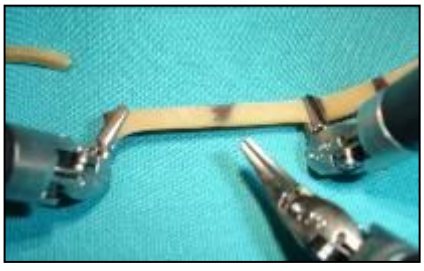
moves the camera toward position “A”; time stops when the rubber band has been placed at back at position “A” by the left needle driver.



10) Care must be taken to avoid dropping the rubber band outside of the field of view or avulsing the models.
11) Clutching and camera movement are required to successfully perform this task.
12) Scoring formula: Score = 300 – time – 10 (sum of errors)
13) Cutoff/maximum time allotted = 300 seconds
14) Proficiency Score: 242 (58 seconds; no errors)

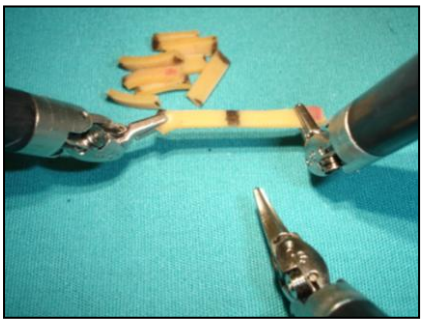
K. Task 7: Running and Cutting Rubber Band



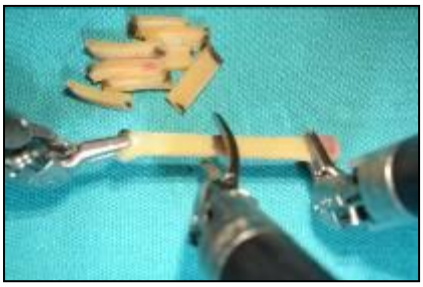


1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (scissors), standard rubber band (12cm length) with 10 equally marked segments (at 1cm intervals); the ends are marked in red and the marked segments in black, and stopwatch.
2) This task uses a 12cm long rubber band model. The rubber band is divided, and 10 marked segments (at 1cm intervals) are placed. Both ends of the rubber band are marked with red segments indicating beginning and end points.
3) The trainee must grasp the rubber band using both needle drivers, apply tension (adequately stretching each segment), activate the 4th arm (scissors), and cut the rubber band in between each marked interval. This process is then repeated until all 10 marked segments have been cut. Clutching and 4th arm activation is required to successfully perform

this task.



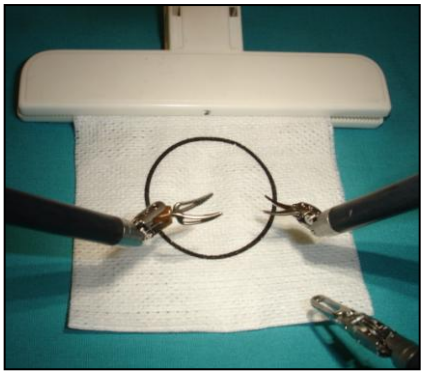
4) Before beginning the task, the instruments must be “zeroed” and the camera centered.
5) The trainee first grasps the rubber band with left and right needle drivers slightly lifting it up from the surface.



6) Once adequate tension has been applied, and an adequate portion of the marked segment is exposed, the trainee then activates the 4th arm and cuts in between the exposed black marked segment.
7) The trainee then deactivates the 4th arm, and repositions both needle drivers to expose the next black marked segment.

8) The 4th arm is then re-activated and the trainee cuts the marked segment.
9) This process is repeated until all 10 marked segments have been cut.
10) Cutting of more than one marked segment in a single grasp is not allowed. Care must be taken to cut directly between each of the marked segments.
11) Time starts when the rubber band is first grasped; time stops when the final marked segment has been cut and released by the right needle driver.
12) Scoring formula: Score = 300 – time – 10 (sum of errors)
13) Cutoff/maximum time allotted = 300 seconds
14) Proficiency Score: 202 (98 seconds; no errors)

L. Task 8: Pattern Cut

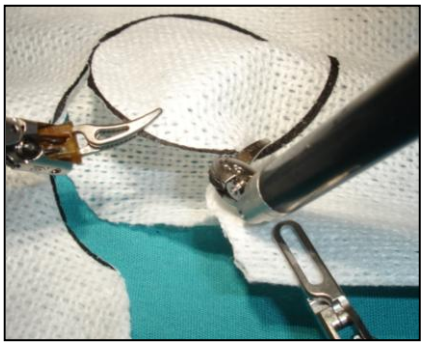
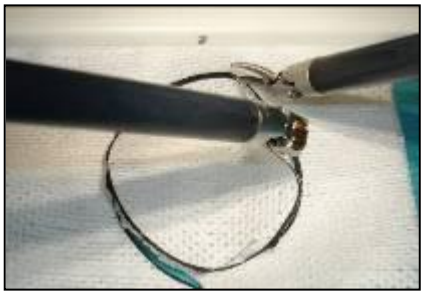


1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, left hand (Maryland grasper), right hand (scissors), 0º camera, 4th arm (Prograsp™ or Cadiere grasper), FLS pattern cut testing template (inserted into a plastic clip and

affixed within the box trainer with Velcro), and stopwatch.

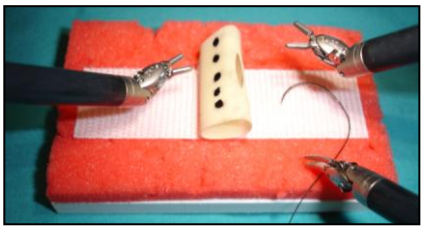
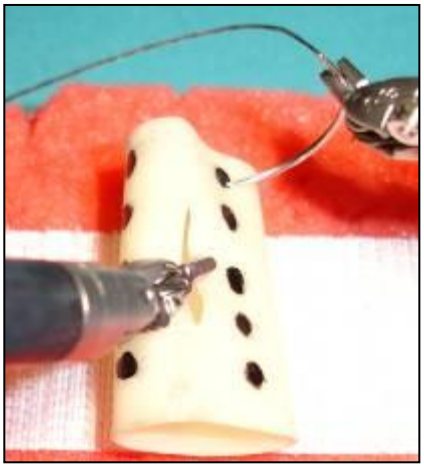
2) This task uses the pattern cut testing gauze from the FLS program (Task 2: Pattern Cut) with no modifications. The gauze is securely placed within a plastic clip and affixed using Velcro. Only a single-layer of gauze must be cut for completion of this task.
3) Before beginning the task, the instruments must be "zeroed".
4) The trainee must grasp the gauze with the 4th arm (Prograsp™) grasper and cut along (and within) the circular stamp using the left Maryland grasper (for traction) and right scissors (for cutting). The trainee must only cut through one layer of gauze; cutting the 2nd layer is allowed, but optional. Clutching and camera movement are required to efficiently perform this task.
5) The trainee first grasps the inferior edge of the gauze with the 4th arm grasper to apply tension to the gauze during performance of the task.
6) The trainee then uses the clutch to activate the scissors and the left Maryland grasper is used to pull traction on the gauze while gentle cutting (inward and towards the circular template) is initiated with the scissors.
7) When the edge of the circle is reached, articulation of the scissors is required and cutting within the marked segment is then carried out.
8) Camera movement, scissor adjustment, and clutching are encouraged during cutting of the circular template.
9) When the entire circle has been cut, the task is complete.

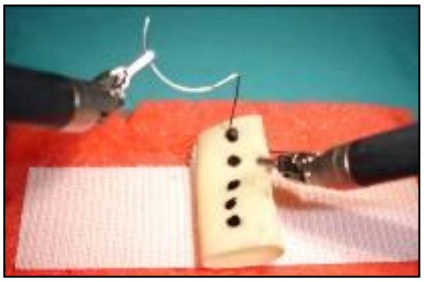



10) Time starts when the gauze is first grasped; time stops when the circular template is completely cut.
11) Care must be taken to avoid cutting outside the lines or pulling the gauze out of the plastic clip.
12) Scoring formula: Score = 300 – time – 50 (sum of errors)
13) **NOTE:** errors are more heavily weighted (50 vs. 10) than the other 8 tasks.
14) Cutoff/maximum time allotted = 300 seconds
15) Proficiency Score: 147 (153 seconds; no errors)

M. Task 9: Suture (Running)



1) Ensure that all materials required are at hand and accessible: da Vinci robotic surgical system, FLS laparoscopic box trainer, foam suturing board (centered in the box trainer and secured using Velcro), Penrose drain (FLS suturing model) with a 2cm slit and 5 pairs of pre-inked targets (10 total), firmly affixed to the foam suturing board with Velcro, 2-0 silk suture on a tapered needle (15cm length), left hand (needle driver), right hand (needle driver), 0º camera, 4th arm (scissors), and stopwatch.
2) This task uses the Penrose drain suturing model from the FLS program (Task 5: Intracorporeal Suturing) with modifications. 5 pairs of inked targets are placed on either side of a 2cm slit.
3) Before beginning the task, the instruments must be “zeroed”.
4) The trainee must perform a running suture by approximating a 2cm simulated incision within the FLS suturing model. A surgeon’s knot (followed by 2 square knots) must be tied on the first and last pairs of inked targets.
5) The trainee first grasps the needle with the left needle driver, and carefully positions it within the right needle driver in a forward position.

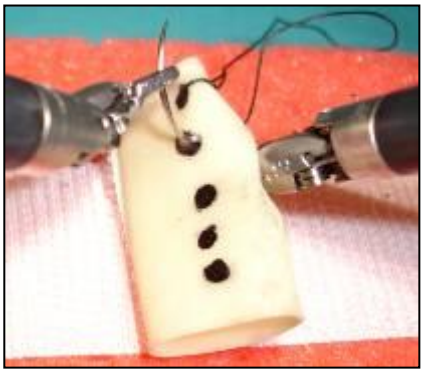
Alternatively, the needle may be grasped with the right needle driver and gently positioned using the left needle driver. Care must be taken to avoid bending or damaging the needle.

6) The left needle driver is then used to grasp and manipulate the front (or within the incision) of the suturing model while passing the needle through the 1st inked target with the right needle driver.

7) The needle is then passed through the 2nd inked target using a “single-bite” technique.

8) The needle is then pulled completely through the suturing model with either needle driver leaving a short suture tail for subsequent knot-tying.

9) The suture is then grasped with the right needle driver, and 2 loops are wrapped around the tip of the left needle driver. Alternatively, the needle (as opposed to the suture) may be grasped to form the loops.



10) The left needle driver is used to pull through the suture tail and tied securely in place completing the surgeon’s knot. Care must be taken to avoid excessive force while placing and tying the knot.

11) Using the FLS protocol for laparoscopic suturing and knot-tying (i.e. alternating hands), the left needle driver is then used to perform a single loop around the tip of the right needle driver.

12) The suture tail is then grasped and pulled through this loop, thereby completing a square knot.

13) Alternating hands once more, this process is repeated, and the 3rd square knot is tied. Care must be taken to leave a very short length of tail to allow for adequate length for subsequent suturing and knot-tying.

14) The trainee then activates the 4th arm (scissors) by quickly tapping the clutch pedal, and cuts the suture tail to 1cm in length. Alternatively, cutting may be completed at the very end of the task to avoid multiple clutching.
15) The needle is then re-grasped, and suturing of the 2nd through 5th pairs of inked targets is performed. Care must be taken to tighten the suture while progressing toward the final pair of inked targets.
16) When the 5th pair of inked targets is reached, the trainee must leave a short loop to use as a tail for subsequent knot-tying.
17) In a similar manner as before, the trainee then ties a surgeon's knot followed by 2 square knots.
18) The trainee then activates the 4th arm (scissors) by quickly tapping the clutch pedal, and cuts the suture tail to 1cm in length thereby completing the task.
19) Care must be taken to avoid excessive manipulation and handling of the suture (so as not to fray or break it), suturing model (avulsion), and needle (separation/breakage).
20) Time starts when the needle is first grasped; time stops when the final suture tails have been cut to 1cm in length.
21) Scoring formula: Score = 600 – time – 10 (sum of errors)
22) Cutoff/maximum time allotted = 600 seconds
23) Proficiency Score: 340 (260 seconds; no errors)

VI. COMMON ERRORS

In this section, errors for each of the 9 tasks are described in detail. These errors are also discussed during the video tutorial. Specifically, the tutorial describes strategies to avoid these errors. Learners are also oriented to the scoring system which is based in part on these errors. In the written description below, the penalty points associated with each error are provided for scoring purposes.

A. Task 1: Peg Transfer

1) Pegs dropped out of the field of view
    1. 1-point for each peg dropped

B. Task 2: Clutch and Camera Movement

1) Red dot visualized
    1. 1-point for each dot seen
2) Corners of target shape not in view
    1. 1-point for each occurrence

C. Task 3: Rubber Band Transfer

1) Dropping rubber bands outside of the field of view
    1. 1-point for each occurrence
2) Avulsion of model
    1. Score of zero

D. Task 4: Suture (Simple Interrupted)

1) Accuracy = Sum of distances in (mm) needle passed outside of each colored segment
2) Tissue Gap (Air Knot) = Sum of distances in (mm) between edges of model at each set of targets
3) Slippage = Measured by cutting tails to 1cm and “busting” the knot using pointed scissors
    1. 0 points for secure knot
    2. 10 points for slippage >3mm
    3. 20 points for disruption
4) Breakage = If ligature is broken during any portion of the exercise
    1. 20 points if ligature is broken
    2. 1-point during each tissue bite phase
5) Tails = Failure to cut tails to ≤1cm in length
    1. 1-point each occurrence
6) Bunny ears = incorrect knot
    1. 1-point each occurrence
7) Frayed suture
    1. 1-point each occurrence
8) Avulsion of model
    1. Score of zero

E. Task 5: Clutch and Camera Peg Transfer

1) Peg dropped outside of the field of view

1. 1-point for each occurrence

F. Task 6: Stair Rubber Band Transfer

1) Dropping rubber bands outside of the field of view
    1. 1-point for each occurrence
2) Avulsion of model
    1. Score of zero

G. Task 7: Running and Cutting Rubber Band

1) Cutting outside of the black marks
    1. 1-point for each occurrence

H. Task 8: Pattern Cut

1) Cuts outside of the marked line (either side)

I. Task 9: Suture (Running)

1) Accuracy = Sum of distances in (mm) needle passed outside of each colored segment
2) Tissue Gap (Air Knot) = Sum of distances in (mm) between edges of model at each set of targets
3) Slippage = Measured by cutting tails to 1cm and “busting” the knot using pointed scissors
    1. 0 points for secure knot
    2. 10 points for slippage >3mm
    3. 20 points for disruption
4) Breakage = If ligature is broken during any portion of the exercise
    1. 20 points if ligature is broken
    2. 1-point during each tissue bite phase
5) Tails = Failure to cut tails to ≤1cm in length
    1. 1-point each occurrence
6) Bunny ears = incorrect knot
    1. 1-point each occurrence

VII. EXPERT PERFORMANCE

Performance goals for each of the 9 tasks were derived by averaging the scores of one faculty surgeon during 5 consecutive repetitions of each task. Data were suitably homogeneous and there were no outliers (>2 s.d. beyond the mean). A normalized score was defined as the task score divided by the proficiency score; a composite score was defined as the sum of all 9 normalized task scores. Subsequent studies confirmed the suitability of these expert performance levels via statistical comparisons with other experts and a large cohort of trainees. A

42-minute instructional video illustrating appropriate techniques and pitfalls for this curriculum was created to serve as a pre-orientation tutorial and utilized by trainees during self-training and practice sessions as needed.

Tasks	Proficiency Score*	Proficiency Time*	Scoring Formula*
1	234	66 seconds (no errors)	300 – time – 10 (sum of errors)
2	248	52 seconds (no errors)	300 – time – 10 (sum of errors)
3	229	75 seconds (no errors)	300 – time – 10 (sum of errors)
4	509	91 seconds (no errors)	600 – time – 10 (sum of errors)
5	251	49 seconds (no errors)	300 – time – 10 (sum of errors)
6	242	58 seconds (no errors)	300 – time – 10 (sum of errors)
7	202	98 seconds (no errors)	300 – time – 10 (sum of errors)
8	147	153 seconds (no errors)	300 – time – 50 (sum of errors)
9	340	260 seconds (no errors)	600 – time – 10 (sum of errors)

*Expert-derived proficiency levels

VIII. RECOMMENDATIONS FOR PRACTICE

A. Distributed Practice

1) For optimal benefit, self-training and practice should be conducted in a distributed fashion in which individual training sessions are limited to relatively small durations in length. We recommend a maximum duration of up to 2 hours per training session (not to exceed 2 sessions in one day) so as to ensure that mental and physical fatigue are minimized and maximum retention and acquisition of technical skills is achieved. Practice sessions may be conducted (based on the trainee's discretion and time availability) multiple times per week. Repetitive practice, during dedicated training sessions, must be performed in order to reach proficiency and demonstrate mastery of skills.

B. Structured Practice

1) This curriculum was methodically structured and arranged in increasing level of difficulty with Task 1 being the least difficult and Task 9 the most difficult. Trainees must practice to proficiency on each task before proceeding to the next. This is to ensure that skills from the previous task have been mastered and can be applied in the performance of subsequent tasks.

C. Practice Order

1) The 9 tasks for this curriculum must be practiced in order. Trainees should begin at Task 1 and move to the following task once expert

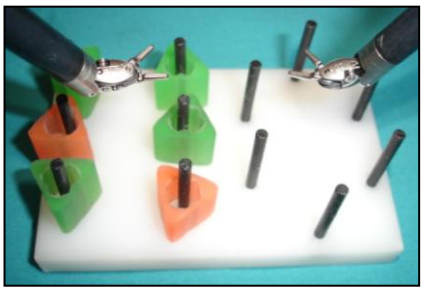
level proficiency (or the maximum number of 80 repetitions) has been achieved or documented, respectively.

D. Track Performance

1) Scores from each repetition are recorded and documented by the designated proctor and the trainee is provided with ongoing feedback. By monitoring trainee performance, mentoring and feedback can be provided to individuals who are having difficulty acquiring skills.

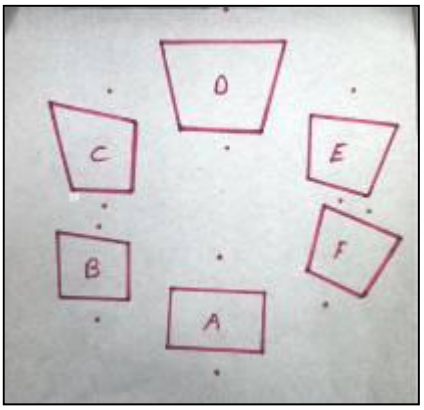
IX. SUPPLIES & STATION SETUP

A. Task 1: Peg Transfer



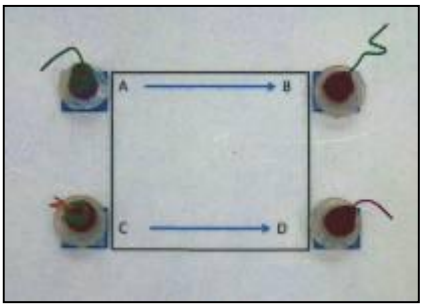
1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) FLS pegboard (securely placed within the box trainer using Velcro)
4) 6 rubber pegs
5) Left hand: needle driver
6) Right hand: needle driver
7) 0º camera
8) 4th arm: inactive
9) Stopwatch

B. Task 2: Clutch and Camera Movement



1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Left hand: no instrument
4) Right hand: no instrument
5) 0º camera
6) 4th arm: inactive
7) Custom-made template with 6 four-sided geometric shapes arranged in a clockwise manner (labeled from "A" to "F"). Red dots are placed above and below each shape representing errors.
8) Stopwatch

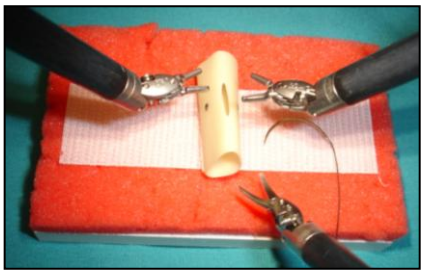
C. Task 3: Rubber Band Transfer



1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer

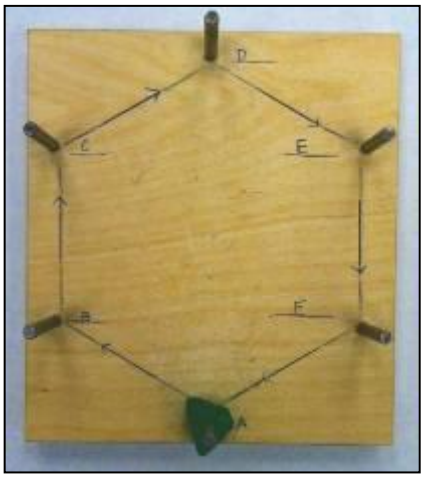
3) Left hand: needle driver
4) Right hand: needle driver
5) 0º camera
6) 4th arm: inactive
7) Custom-made template with commercially available models and rubber bands (The Chamberlain Group, Great Barrington, MA; www.thecgroup.com)
8) Stopwatch

D. Task 4: Suture (Simple Interrupted)



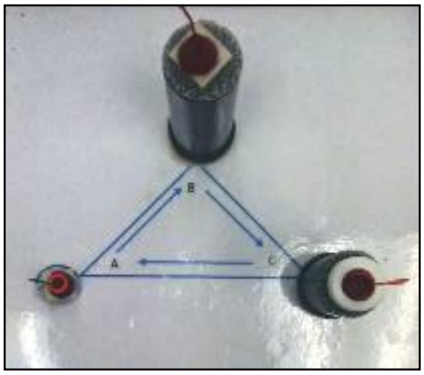
1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Foam suturing board (centered in the box trainer and secured using Velcro)
4) Penrose drain (FLS suturing model) with 2 pre-inked targets
5) 2-0 silk suture on a tapered needle (12cm length)
6) Left hand: needle driver
7) Right hand: needle driver
8) 0º camera
9) 4th arm: scissors
10) Stopwatch

E. Task 5: Clutch and Camera Peg Transfer



1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Left hand: needle driver
4) Right hand: needle driver
5) 0º camera
6) 4th arm: inactive
7) Custom-designed wooden board with 6 metal posts inserted within it and arranged in a clockwise manner and labeled “A” to “F” on a hexagonal pattern.
8) One rubber peg
9) Stopwatch

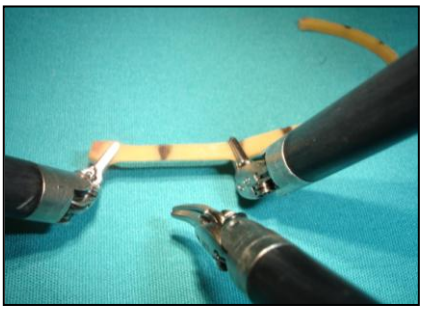
F. Task 6: Stair Rubber Band Transfer



1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Left hand: needle driver

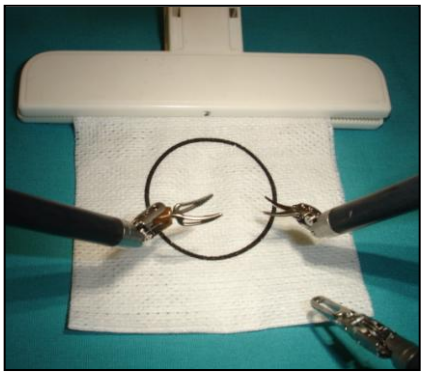
4) Right hand: needle driver
5) 0º camera
6) 4th arm: inactive
7) Custom-made template with commercially available models and rubber bands (The Chamberlain Group, Great Barrington, MA; www.thecgroup.com)
8) Stopwatch

G. Task 7: Running and Cutting Rubber Band



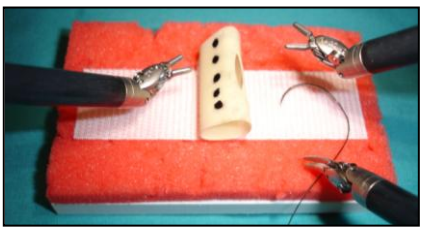
1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Left hand: needle driver
4) Right hand: needle driver
5) 0º camera
6) 4th arm: scissors
7) A divided 12cm long rubber band model, marked with 10 inked segments (at 1cm intervals); the ends of the rubber band are marked with red segments
8) Stopwatch

H. Task 8: Pattern Cut



1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Left hand: Maryland grasper
4) Right hand: scissors
5) 0º camera
6) 4th arm: Prograsp™ or Cadiere grasper
7) Pattern cut testing gauze from the FLS program (Task 2: Pattern Cut) with no modifications
8) Plastic clip
9) Stopwatch

I. Task 9: Suture (Running)



1) da Vinci robotic surgical system
2) FLS laparoscopic box trainer
3) Foam suturing board (centered in the box trainer and secured using Velcro)
4) Penrose drain (FLS suturing model) with 2cm slit and 5 pairs of pre-inked targets (10 total)
5) 2-0 silk suture on a tapered needle (15cm length)

6) Left hand: needle driver
7) Right hand: needle driver
8) 0º camera
9) 4th arm: scissors
10) Stopwatch

X. TIME LENGTH FOR MODULES

A. Online Didactic Video-Based Tutorial

1) The online didactic video-based tutorial consists of 1-hour modules (for Standard, S, or SI systems).
2) Completion of the online tutorial is followed by a 33-40 multiple-choice question self-assessment exam.

B. Half-day Interactive Hands-On Orientation and Pre-Test Session

1) A 4-hour hands-on orientation and pre-test period is conducted for all trainees participating in this curriculum.

C. Video Tutorial

1) The video tutorial consists of a comprehensive 42-minute tutorial demonstrating correct performance of each of the 9 tasks as well as illustrating pitfalls and error avoidance strategies.

D. Training (Self-Practice) Duration

1) To adequately address time constraints due to clinical responsibilities and residency training obligations, trainees are allotted a 2-month period to complete the training portion of this curriculum.
2) On average, 71.6 ± 28.2 repetitions (for all 9 tasks) and 5.0 ± 1.4 hours (during 3-8 practice sessions) are required to complete training and reach the proficiency-based level for this curriculum.

E. Post-Test

1) A 1-hour (one-on-one) proctored post-test exam will be scheduled by the trainee upon completion of all other curricular components.