Practical Skills Syllabus

Institute of Surgical Research
University of Szeged

Szeged, 2007
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Introduction

Medical education has been based on apprenticeship techniques since the era of Hippocrates. Two of the major challenges that confront this traditional teaching system are the imperative to maintain patient’s safety and the accelerating need to cover the rapidly changing technical aspects of medicine. Furthermore, proficiency in practical skills only comes from practice; the more the skill is performed, the more fluent the performance becomes.

Simulation offers a perfect solution. It is a tool which allows participants of the healthcare to behave and perform as they would in a “real” environment. The benefits of simulation include practice without causing harm (alternative to learning ‘on patients’), providing framework for learner-centered learning, with expert tuition and feedback. Indeed, it has been shown that complex clinical skills can be taught and practiced in a step-by-step fashion until students achieve confidence.

Today the Institute of Surgical Research at the University of Szeged runs several hands-on skills courses using realistic clinical settings, interactive videos and virtual reality (VR) techniques. Among these, VR is perhaps the most important component for the future: would-be doctors could use computer simulations so accurate and vivid that they look, sound and feel like the real task. The other promise of this kind of technology lies in remote teaching—connecting students and teachers no matter where they are. A superfast communication network would transmit the program to any computer, allowing students and teachers across a region to share and learn from the same experience. The University of Szeged has recently received a grant to build a small-scale prototype that would link the Skills Laboratory of the Institute of Surgical Research to the computers of the University of Timisoara, Romania. The aim of our INTERREG HURO-0602/086 project is to build an infrastructure where tools of telemedicine can significantly facilitate the transfer of knowledge and should result in marked improvements of the education systems. The project will focus on using simulation for remote, real-time teaching of surgical techniques, microsurgical and monitoring skills. Some parts of the project, such as telemedicine with microsurgical models will be integrated into the curriculum of the Medical School by 2008. Other parts, such as the use of VR haptic interfaces, will require more development time.

These skills are taught in the skills laboratory and in the students’ operating theater at the Institute of Surgical Research in a simulated, life-like environment. The “Pius Brânzeu” Education Center of the Victor Babes University of Timisoara has almost the same structure and possibilities. Up-to-date, modern communication devices and “virtual reality” aids could be used to connect the dual-centric educational work, to realize cooperation between teachers and students alike, and to multiply the results. We hope that the final outcome of our action will be a “virtual education center”. A network will be built, which allows for the sharing of expensive devices not available at both sites, to connect practical courses which require significant human resources or organization work, to level and to apply suitable teaching programs. This system allows for the possibility of the most effective use of available sources and may serve as an interface enhancing inter- and intra-regional relationship. The teaching program ensures a steady bilateral access to information (on-line connections, telemedicine, e-learning, organization of joint symposia, etc.) which strengthens the partnership continuously. The running of complementary “skills” systems provides an exceptional possibility to build interregional intellectual connection, allows for the approximation of a considerable segment of the higher education of the two cities, strengthens mobility and increases the intellectual potentials of the region.

This syllabus is providing basic information for the participants of these skills courses. The themes of the courses are organized into modules. Each module includes an outline of topics, objectives, key terms, and a list of activities. Questions and evaluation protocols help students to measure their progress every step of the way toward the acquisition of sound techniques in each skill area.

Competence involves assessment of the students’ knowledge, practical skills and attitude. Utilizing standardized test stations and checklists is an ideal method for such assessment. Drawing from the experience of contemporary European medical education, students are now required to manifest their practical skills during a performance-based objective exam or Objective Structure Clinical Examination (“OSCE”). The utility, reliability and validity of OSCEs in testing undergraduates in medicine are well established. Every student sees the same problem and performs the same tasks in the same time frame, and these tasks are representative of those faced in real clinical situations.

The chapters have been compiled by the staff and PhD students of the Institute of Surgical Research (Dr. Ágnes Adamicza, Dr. Mihály Boros, Dr. Tamás Jánossy, Dr. József Kaszaki, Dr. Andrea Szabó, Dr. Csilla Torday, Gabriella Varga, Dr. Gábor Erős and Dr. Miklós Czöbel), together with Zoltan Szabo (MOET Institute, San Francisco, USA) and Drs. Mihai Ionac and Lucian Iiga (University of Timisoara, Romania). We wish to acknowledge the creative illustrations by Mrs. Kálmáné Csíkszentimrei and the activities of Dr. Miklós Czöbel, which have made it possible to maintain a highly effective website. The syllabus and further course materials (Surgical techniques. Textbook for medical students. Szeged, Innovariant, 2006; Monitoring in medical practice. Basic medical skills. Szeged, Innovariant, 2007, and Magnified surgery. Szeged, Tiszapress, 2005) can be downloaded from http://web.szote.u-szeged.hu/expsur.

Szeged, 2007
“A” MODULES

This program familiarizes the students with the physical environment of the operating room, the roles of the surgeon and other team members. An introduction to surgical care is presented including concepts of asepsis, scrubbing, gowning, gloving, and creation of a sterile field for selected surgical procedures. The preparation and care of supplies and equipment used for surgical procedures is also included. The course is focused on understanding of pre- and intraoperative and immediate postoperative patient care needs. Special circumstances which may occur during surgical care are addressed. The students are given the opportunity to develop correlating competencies through selected guided experiences in the simulated operating room and in the skills laboratory. The modules below consist of step-by-step instructions.
A1. MODULE – ASEPSIS SKILLS

Asepsis skills

Learning objectives/aims: To ensure safety and asepsis in the operating room. Upon completion of this course, students will be able to summarize the relationship between hand hygiene and the acquisition of healthcare-associated pathogens, state accepted principles of surgical hand antisepsis.

Note: Students are expected to wear low-heeled slip-proof shoes to prevent accidental injury, wear no dangling jewelry, maintain personal hygiene and keep fingernails cut short and clean.

Site: Students’ operating room (OR). Here the students are provided with didactic and clinical activities related to complex invasive procedures and equipment.

Themes: Scrubbing, gowning and gloving, principles of aseptic technique, how to move around the operating room table.

Procedures:
1. Perform a surgical handwash
2. Put on sterile gowns
3. Put on sterile gloves
4. Remove “soiled” gowns and gloves
5. Textiles and drapes in the operating room
6. Preparing the operative site—skin cleansing
7. Draping and isolation of the operative site

Section 1.
Perform a surgical scrub and rinse at scrub sink

Shoe covers, cap and mask is worn. Head gear (cap) must completely cover both the hair and the forehead. The mask must be sufficiently large to cover both the hair and the forehead. The mask strings, soap dispensers).

Steps
- Roll up sleeves if needed. Check for open sores, trimmed fingernails, and that you are not wearing any nail polish or jewelry.
- Turn on water. Check for timer or clock. Look for areas that may cause contamination when rinsing (hanging mask strings, soap dispensers).
- Clean nails if necessary while holding them under the running water. Discard nail cleaner in trash container.
- Cover the entire area to be washed with a copious amount of soap (from fingertips to 5 cm above both elbows). This is the time to check the clock and time your scrub.
- Pick up scrub brush. Scrub over and underneath nails (min. 10 strokes). Do not touch the faucet with your scrub brush or you must get a new brush and start timing again. Do not return to get more water unless absolutely needed.
- Scrub second hand—over and underneath nails (min. 10 strokes).
- Scrub first hand—over and underneath nails (min. 10 strokes).
- Turn on water. Check for timer or clock. Look for areas that may cause contamination when rinsing (hanging mask strings, soap dispensers).
- Clean nails if necessary while holding them under the running water. Discard nail cleaner in trash container.
- Cover the entire area to be washed with a copious amount of soap (from fingertips to 5 cm above both elbows). This is the time to check the clock and time your scrub.
- Pick up scrub brush. Scrub over and underneath nails (min. 10 strokes). Do not touch the faucet with your scrub brush or you must get a new brush and start timing again. Do not return to get more water unless absolutely needed.
- Scrub second hand—over and underneath nails (min. 10 strokes).

Section 2.
Donning gowns

Steps
- The hands are held above the elbows, in front of the chest.
- Go to the container that is on a stand. Open up the cover with the foot pedal.
- Pick up a sterile gown with your right hand while keeping the others with the left hand to prevent them from pulling out.
- Pick up the gown at the center. It is folded so that the inner surface is exposed to you when you pick it up. Never touch the outer surface.
- Step back away from sterile field to open up.
- Open gown by holding at neck line facing correct direction (inside of gown faces scrub attire), out away from your body and the container and sufficiently high so that it will not touch the floor.
- Holding the gown by the inside at the neckline allow it to unfold gently ensuring that the gown does not come into contact with anything nonsterile.
- Insert both arms into the armholes, keeping your arms extended as you do so. Wait for the scrub nurse to assist you by pulling the gown up over the shoulders and tying it.
- The scrub nurse grasps the inner surface of the gown at each shoulder and pulls the gown over your shoulders and the sleeves up over the wrist. The scrub nurse assists you in fastening the gown at the back.
- Keep your hands above the level of your waist and do not touch anything.
Section 3.
Donning gloves

Steps
- The scrub nurse holds the left handed glove open with her fingers beneath the cuff so that her glove does not come in contact with your skin. The palm of the glove faces to you.
- Put two fingers of your right hand into the opening.
- Pull the inner side of the glove toward yourself so that a wide opening is created.
- Slip your left hand into the glove so that the glove cuff covers the sleeve cuff.
- When you put on the right handed glove, place the fingers of your gloved left hand under the right glove cuff to widen the opening and thrust your right hand into the glove.
- You may now adjust your gloves so that to fit comfortably on the hands.

Section 4.
Remove gown and gloves

Steps
- Untie strings at wrists and waistline of gown. Ask the circulator nurse to unfasten neckline.
- Remove gown first before removing gloves.
- Do not touch any areas that would cause cross-contamination.
- Roll gown carefully inside out.
- If your gloves become soiled or damaged, you must change them at once. Grasp one of the gloves near the cuff and pull it partly off. The glove will turn inside out. It is important to keep the first glove partially on your hand before removing the second glove to protect you from touching the outside surface of either glove with your bare hands.
- Leaving the first glove over your fingers, grasp the second glove near the cuff and pull it partly of the way off. The glove will turn inside out. It is important to keep the second glove partially on your hand to protect you from touching the outside surface of the first glove with your bare hand.
- Pull off the two gloves at the same time; be careful to touch only the inside surfaces of the gloves with your bare hands.

Section 5.
Draping skills.
Textiles and drapes

Today, conventional cotton fabric is still being widely used. Draping materials must provide an effective barrier against the spread of infection and should be sufficiently resistant to withstand mechanical stress even in the presence of liquids.

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<td>Fenestrated procedural sheet, large</td>
<td>Large hole in its middle area; covering the patient’s body. Reusable or disposable (single use)</td>
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<tr>
<td>Fenestrated procedural sheet, small</td>
<td>Hole in its middle area; covering a smaller operative site (e.g. in case of emergency)</td>
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<tr>
<td>Procedural full sheet</td>
<td>Isolation of the total body surface</td>
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<tr>
<td>Procedural half sheet</td>
<td>Isolation of half part of the body</td>
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<tr>
<td>Procedural quarter sheet</td>
<td>Isolation of a smaller area of the body in minor surgery</td>
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<tr>
<td>Textile towels</td>
<td>Direct isolation of the wound edge</td>
</tr>
<tr>
<td>Gauze sponges</td>
<td>For skin cleansing; handling bleeding</td>
</tr>
<tr>
<td>Whole, etc. adhesive drapes with or without fenestration</td>
<td>The drapes are available with adhesive tape for easy placement and use</td>
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- Use at least four (or more) sheets for isolation of the operative site.

Section 6.
Preparation of the operative site

Learning objectives/aims: Preparation of the operative site (skin cleansing and draping). The procedure is performed on phantoms on the operating table. All supplies used (towels, gauze sponges, sponge forceps and gloves) must be sterile.

Steps
- The patient (phantom) is covered by a special full sheet which is positioned so that a hole incorporated in it lies over the operative site.
- The first assistant (Student 1) puts on sterile textile gloves alone after the surgical hand scrub and before dressing.
- A sponge holding clamp and some sponges are given to him/her by a “sterile”, scrubbed and dressed scrub nurse (Student 2) in an aseptic manner.
- Student 1 grips a sponge in the sponge holding clamp, and holds it with an extended arm toward a “non-sterile” person (assistant) who pours petrol/povidone-iodine to the sponge above a bowl without any contact.
- Student 1 performs the skin cleansing of the operative field in order of the next steps: 1. Removal of the fat from the skin surface with petrol. 2. Repeating the previous procedure with a new sponge. 3. Disinfection with anti-septic paint (povidone-iodine or 1–5% iodine tincture is applied). 4. Repeating the previous procedure on a smaller area with a new sponge. 5. Soiled sponges are collected in a bowl. Note: Scrubbing is performed outward from the incision site and concentrically, and it is forbidden to return to a cleansed area with the same sponge.
Section 7.
Draping the operative site

After the skin preparation, the disinfected operating area must be isolated from the nondisinfected skin surfaces. The isolated area is always smaller than the scrubbed area. Students 1 and 3 (scrubbed and dressed persons, first assistant and surgeon) execute this procedure in order of the next steps:

- Student 2 (scrub nurse) gives a specially folded sheet from the Mayo stand to Student 3 and Student 1. They unfold this base sheet and isolate the patient’s leg.
- The sterile Mayo stand is then moved near to the operating table.
- The second sheet is used to drape and isolate the patient’s head; it is fixed by a Jones or Schaedel towel-clip to the guard.
- The two side-sheets are then placed.
- The drapes can be moved outward from the sterile field, but not toward it. The sheets are fixed with four Backhaus towel clips.

Evaluation

Section 1.
- This student maintained sterile technique during the procedure (25 points).
- Touched an unsterile item or area, acknowledged occurrence and readily offered a solution to the break in technique (first offense 0 points, second offense minus 5 points, each additional offense minus 5 points).
- Did not acknowledge gross-contamination of fingers, hands, or arms while performing this procedure (“failed”).
- The following are considered serious breaches of the rules of asepsis: Face-masks being allowed to hang down during use; using the scrubbed or gloved hands to handle a used face-mask (minus 5 points).

Section 2–4.
- This student maintained sterile technique during the procedure (25 points).
- Touched an unsterile item or area, acknowledged occurrence and readily offered a solution to the break in technique (first offense 0 points, second offense minus 5 points, each additional offense minus 5 points).
- Did not acknowledge gross-contamination while performing this procedure (“failed”).

Sections 5–7.
Students should perform the whole procedure in the right order and with maximal compliance with the rules of sterility (25 points). Typical mistakes (minus 3 points/mistake):
- Sterility is broken.
- The direction of scrubbing is not proper.
- The order of scrubbing is not proper.
- Returning to a cleansed area with the same sponge.
- The order of draping is not proper.
- Drapes are moved toward the sterile field.
- Fixation with Backhaus towel clips is not proper.
A2. MODULE

Instrumentation skills

Learning objectives/aims: To educate participants in safe and proper instrument handling practices and appropriate instrument choice.

Site: Skills laboratory, computer room

Procedures:
1. Cutting and dissecting instruments
2. Grasping instruments
3. Retracting instruments
4. Wound-closing instruments

Section 1.
Cutting and dissecting instruments

The Suture Tutor computer program (Medical Skills Ltd., UK) is used to teach proper handling of scalpels. Click on “Instruments”, then “Scalpel” icons. The menu points of “Principles” demonstrate the proper handling of scalpels.
- Hold the scalpel like a pen for maximum control to make a short or fine incision.
- For a long straight incision, hold the scalpel as a fiddle bow (grip it horizontally between the thumb, index and middle fingers; the ring and little fingers can hold the end of the handle).

Menu points of “Scalpel blades” show the different size blades and handles: a #3 handle is used with the smaller #10–15 blades, and a #4 handle with the larger #20–23 blades. Wide-bladed scalpels with a curved cutting edge are used for the incision of skin and subcutaneous tissues. Thin-bladed sharp-tipped scalpels serve for the opening of blood vessels, ducts and abscesses.

Menu points of “Mounting and removing the blades” demonstrate how a disposable blade could be mounted or removed to/from the stainless steel handle.

The next pages demonstrate the proper handling of scissors. Click on the “Instruments” → “Scissors” menu.
- Proper handling of scissors: The thumb and ring finger are put into the finger rings. The index finger is placed on the distal part of the shanks, thereby stabilizing the instrument. The cut is usually made close to the tips of the blades.
- Proper handling of suture scissors (dressing or Cooper scissors). These are straight, sharp and robust. Use them only for cutting sutures, threads, and not tissue.
- For cutting or preparation of tissues, use Mayo scissors or the finer Metzenbaum scissors.

Section 2.
Grasping instruments

Click on “Instruments” → “Dissecting forceps” icons. The menu points of “Principles” will demonstrate the proper handling of forceps step-by-step.
- Forceps is used to grasp tissue with delicacy and precision. It is usually held in the nondominant hand.
- It should be held like a pen in the midway position, gripping between the thumb and index finger.

Menu points of “Surgical clamps”
- These instruments should be held like scissors: the thumb and ring finger should be put into the finger rings, and the clamp is stabilized with the index finger. The lock can be opened by pressing down one of the finger rings while elevating the other one with the ring finger; in this way, the interlocking teeth are moved from one another.
- Hemostatic forceps: they are used to stop bleeding by grasping and clamping the ends of cut vessels or for preventive hemostasis by applying them before cutting the vessel. They can be used also for blunt dissection.
- Traumatic hemostatic forceps (crushing hemostats): Péan, mosquito, Kocher, Lumnitzer (Kocher with long shanks). The jaws can be straight or curved, while the tips are blunt. The dissector has long shanks and the ends of the jaws are curved at 90°.
- Instruments used for grasping and clamping other tissues and textiles: towel-holding clamps serve to fix the draping towels to the ether screen, to one another and to the skin of the patient (Backhaus towel clamp).

Needle holders have short powerful jaws and long handles, providing a powerful squeezing force. Criss-cross lines cut into the jaws provide a firm grip on a curved needle. Click on the “Instruments” → “Needle holder” menu. “Ratchet mechanism” demonstrates step-by-step how to open and close this instrument.
- Ratchets usually have three notches. Closing the handle will engage the ratchet automatically.
- Opening them requires passive disengagement. To release, you must first squeeze the handles to disengage the ratchet, then separate the handles fractionally while opening them.

Menu points of “Positioning the needle” demonstrate step-by-step how to mount a needle holder with needle:
- The central section of a curved needle is flattened so that it can be held by the needle holder. Grasp the needle on this flat section, about two-thirds of the way from the tip.
- Grasp the needle with the tip of the needle holder’s jaws.
- Angle of the needle is slightly forward in the instrument’s jaws.

Menu points of “Handling the needle holder” demonstrate the proper handling of this instrument.
- Use your ring finger and thumb in the finger holes and handles are stabilized with the index finger, so that you can position the jaws precisely.
Section 3.
Retracting instruments

- Retractors are used to hold tissues and organs aside in order to improve the exposure and hence the visibility and accessibility of the surgical field.
- Main types: hand-held retractors (rake or plain retractors) are held by the assistant; self-retaining retractors (Gosset self-retaining retractor).

Section 4.
Wound-closing instruments

Click to the “Instruments” → “Needles” menus.

- Needles are classified according to the type of the eye, shaft (body) and point. Needle eyes may be conventional, closed or French-eyed, and there are also eyeless needles (atraumatic needles).
- The shape of the body can be triangular (and cutting) or curved/oval in its cross-section.
- The basic types of the needle points are cutting, taper and blunt.
- Depending on their curvature, 1/4 circle (skin, eye or tendon sutures), 1/2 circle (muscle or fascia sutures), 3/8 circle (skin, fascia or gastrointestinal sutures), and 5/8 circle needles (muscle or urogenital sutures) are discerned.

Evaluation (1)

Sections 1–4.

Identify instruments by proper name and classify instruments into categories. Example: write the proper name of each instrument displayed and include descriptive nouns such as the words “SCISSORS” or “CLAMP”, etc. Classify the instrument by choosing the correct category. Place the category title or abbreviation listed below next to each instrument (e.g. CD = cutting/dissecting, W = wound closing, R = retracting/exposing).

SCALPES
- #3 regular scalpel
- #4 scalpel

RETRACTORS
- Rake retractor, dull
- Weitlaner retractor

TOWEL CLIPS
- Towel clips, small sharp, Backhaus

NEEDLE HOLDERS
- Mayo-Hegar
- Mathieu

GRASPING and HOLDING FORCEPS
- Forceps, smooth
- Forceps, with teeth

GRASPING and HOLDING CLAMPS
- Kocher clamp
- Péan clamps: regular, medium or long
- Mosquito hemostat clamp

SCISSORS
- Mayo scissors, curved
- Mayo scissors, straight suture
- Metzenbaum scissors, short
- Metzenbaum scissors, regular

MICROSURGERY
- Microsurgery needle holder, locking
- Microsurgery needle holder, unlocking

Evaluation (2)

Section 1–4.

- The student is able to use an instrument (5 points).
- Typical mistakes (minus 1 point/mistake): holding the scalpel or the scissors with an overhand grip; the blade is grasped during the incision; the handle is grasped far from the blade; the forceps is held incorrectly; using index finger and thumb in the finger holes of the needle holder causes loss of control; holding the needle too near to its tip; holding the needle too near its French-eyed end may cause the buckling or snapping of the needle, etc.
A3. MODULE

Knot tying skills

Suturing and knot-tying skills are essential for a successful practice, regardless of the field of specialization. Students need a solid foundation of knot tying skills in the didactic phase to build upon during clinical situations.

Learning objectives/aims: To teach surgical knot tying appropriate for a variety of suturing techniques

Site: Skills laboratory and computer room

Procedures
1. Two-handed square knot
2. Surgeon’s knot
3. Viennese knot
4. Tying knots with instruments
5. Knotting in depths
6. Knotting under tension

Items needed: Practice boards with different shapes, threads, needle holders (or hemostatic forceps), the Suture Tutor computer program (Medical Skills Ltd., UK).

Section 1.

Two-handed square knot (reef or sailor’s knot)

Steps
- First half hitch: cross the threads, the upper thread is in the right hand.
- Push the upper thread to the left side.
- Insert the right thumb into the loop, upward from below. The left thread is placed on the pulp of the right thumb.
- Grasp the thread with the right thumb and index finger.
- Release the thread from the left hand and pass it through the loop.
- Grasp the thread with the left hand again.
- Apply horizontal tension while tightening the first half hitch.
- Second half hitch: cross the threads in the opposite direction, the upper thread is in the left hand.
- Push the upper thread to the right side over the other thread.
- Insert the right thumb into the loop, upward from below.
- Place the right thread on the pulp of the thumb.
- Grasp the thread with the left thumb and index finger.
- Release the thread from the right hand and pass the thread through the loop.
- Grasp the thread with the right hand.
- Tighten the second half hitch with two hands.

Section 2.

Surgeon’s knot

Steps
- The technique of tying is identical to the two-handed square knot, but during tying the first half hitch the thread is passed twice through the loop.
- Complete the knot with a simple half hitch in the opposite direction.

Section 3.

Viennese knot

Steps
- First half hitch: cross the threads, the lower thread is in the left hand.
- Hold the ends of the thread between the tips of the thumbs and index fingers.
- Place the left hand over the thread.
- Supinate the wrist, the ulnar side of the small finger is laid on the thread.
- Place the right thread on the pulp of the left middle finger, flex the distal phalanx and pull it beneath the left thread.
- The left thread is between the middle and index finger. Close the two fingers and release the ends with the thumb and index finger. Bring the thread through the loop. Tighten the first half hitch.
- Second half hitch: cross the threads in the opposite direction.
- Hold the lower thread between the right thumb and index finger.
- Place the right hand over the thread. Supinate the wrist, the ulnar side of the small finger is laid on the thread.
- Place the left thread on the pulp of the right middle finger, flex the distal phalanx and pull it beneath the right thread.
- The right thread is between the middle and index finger. Close the two fingers and release the ends with the thumb and index finger. Bring the thread through the loop. Tighten the knot.

Section 4.

Instrument tie

Steps
- First half hitch: place the needle holder on the long end of the thread (with atraumatic needle at the end) held in the left hand.
- Loop the thread around the jaws of the needle holder once (or twice in the case of surgeon’s knot).
- Pick up the short free end of the thread with the needle holder.
- Pull it through the loop and tighten the first half hitch by pulling the two ends of the thread in the opposite direction.
- Second half hitch: loop the long end of the thread around the jaws of the needle holder once, but in the opposite direction (place the needle holder under the long end of the thread).
- Grasp the short free end of the thread with the needle holder.
- Pull it through the loop and tighten the second half hitch in the opposite direction from before.
- Tie several (up to 6) such double knots with monofilament synthetic threads.

The tying with instruments is presented by means of a computer program (Suture Tutor) too. The menu points are shown below.

**SUTURING TECHNIQUES—TYING A KNOT**

<table>
<thead>
<tr>
<th>TYING A REEF KNOT</th>
<th>TECHNIQUES FOR ADDITIONAL SECURITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (blue) demo:</td>
<td>1. (blue) demo:</td>
</tr>
<tr>
<td></td>
<td>The ideal reef knot</td>
</tr>
<tr>
<td>2. (blue) demo:</td>
<td>2. (red) video:</td>
</tr>
<tr>
<td></td>
<td>Making a reef knot in two stages</td>
</tr>
<tr>
<td>3. (yellow) video:</td>
<td>3. (yellow) video:</td>
</tr>
<tr>
<td></td>
<td>Placing a simple interrupted skin suture and making an instrument tie on a patient</td>
</tr>
<tr>
<td>5. (blue) demo:</td>
<td>6. (blue) demo:</td>
</tr>
<tr>
<td>Instrument tie:</td>
<td>Instrument tie: The first throw</td>
</tr>
<tr>
<td>The first throw</td>
<td>Instrument tie: The second throw</td>
</tr>
</tbody>
</table>

**PROBLEMS (UNRELIABLE KNOTS)**

**Granny knot**

| 1. (blue) demo: | The asymmetrical granny knot |
| 2. (blue) demo: | The first throw of granny knot tying with instrument |
| 3. (blue) demo: | The second throw of granny knot: the direction is the same as the first throw |

**Slip knot**

| 1. (blue) demo: | The slip knot will tend to come undone |
| 2. (yellow) video: | The slip knot is caused by failing to change the direction of the pull after the first throw |

Section 5.

**Knot tying in cavities**

**Steps**

- Form the half hitches outside the cavity and tighten them in the depth of the cavity.
- Make the first half hitch, form the first loop outside the „cavity” of the practice board.
- Place the index finger of one hand on the thread and advance the loop into the „cavity” while maintaining counter tension on the other thread.
- Form the second loop outside the „cavity”.
- Advance the loop down with the index finger of the other hand while maintaining counter tension on the other thread.

![Fig. 1–3. Knotting in a simulated cavity, knotting in the “abdomen”, and knotting in the “pelvis”](image)
Section 6.
Knotting under tension

Steps
- Tighten the first half hitch, and keep a little tension on the threads while tightening the second half hitch.
- Tighten the first half hitch, and then rotate the threads to the opposite direction to secure it while the second half hitch is formed.
- After tightening the first half hitch, ask the assistant to press the half hitch with his/her index finger. Tighten the second half hitch while the assistant is lifting up his/her finger.
- Tie a surgeon’s knot. The surgeon’s knot is sufficient to hold the tension while the second half hitch is tightened.
- Ask the assistant for holding the skin edges together with a forceps while the knot is tied.

Evaluation (Sections 1–6)
- The knots are correctly tied, they are not loose or too tight (30 points).
- Incorrectly tied knot (minus 5 points each): the threads are not crossed, the knot is loose, the knot is too tight, only one double knot is tied with a monofilament synthetic suture, etc.
Suturing skills

Learning objectives, aims: Participants will take part in a hands-on session teaching a variety of suturing techniques. This requires a specific skill set, excellent eye-hand coordination, manual skills, ability and willingness to improvise when unexpected occurs.

Site: Computer room and students operating theatre

Themes: The topics covered include handling instruments, tying knots, interrupted sutures, simple suture, vertical mattress suture, pulley suture, and continuous subcuticular suture.

Items needed: Kit contents include a skin pad jig, curved dissection scissors, toothed forceps, scalpel handle, scalpel blades, needle holder, suture scissors, curved artery forceps and suture material.

Procedures
1. Simple interrupted suture
2. Vertical mattress suture
3. Subcuticular continuous suture
4. Wound closure in three layers (peritoneum, subcutis, and skin) with continuous and interrupted sutures
5. Clip application

Section 1.

Simple interrupted suture

At the core of the trainer program, there is a multimedia presentation featuring an array of clinical video and computer graphics animations. On the computers in the skills lab, click on "Suture Tutor" icon. When it opens, click on the opening screen. This will take you to the modules; in each module go through the step-by-step component; these parts also have videos and photos. Click on "Suturing techniques" then "Inserting a suture". The menu points of "Minimizing trauma" demonstrate step-by-step how to avoid extra tissue damage:

- A curved needle traveling along the path of its curvature causes minimal trauma.
- Consider its path as a circle that begins before the needle touches the skin and continuous after leaving it.
- The needle should follow this curved path as it enters and passes through tissue.

The next submenu point, "Inserting a suture" (under the main "Inserting a suture" menu) demonstrates step-by-step how you ensure that the needle takes an adequate bite.

- In case in a small wound, using an adequate needle you can take both sides in a single bite.
- As the needle emerges, support the skin next to it (or elevate it) with forceps.
- Take an equal bite on each side and place sutures with great care to ensure that wound edge come neatly together with a good apposition.
- Evert the wound edges slightly by taking a larger bite of the deeper part of the tissue.

Errors
- Using a curved needle along a straight path (instead of its curvature) can cause tissue damage.
- Taking small superficial bites can lead to dead space within the wound.
- Failure to evert the wound may lead to an ugly depressed scar.

Under the main "Suturing techniques", the next menu point is "Interrupted wound closure". This demonstrates step-by-step how to make simple interrupted sutures.

- Grasp and stabilize wound edge with tissue forceps on the far side.
- Start stitch from the far side of the incision, insert the needle through the tissue.
- Simple interrupted sutures pass through the wound at right angles to the skin surface.
- The needle should exit the tissue perpendicular to the wound.
- Stitches should be placed at equal distances. The distance between sutures is about the same as the distance between the wound edge and the point at with the needle enters or leaves the skin. This is usually 5–8 mm.
- A series of independent sutures brings the wound edges gently together.
- Stitches should be inserted to the base of the wound, not leaving dead space.
- Allow for postoperative swelling of the wound, so that do not tie the sutures tightly.
- Knots should be on one side of the wound and never on the wound line.

Section 2.

Vertical mattress suture (sec. Donati)

Under the main "Suturing techniques", click on the menu point of the "Interrupted wound closure" and then on the "Mattress and pulley suture" which demonstrates step-by-step how to make vertical mattress suture.

- A vertical mattress suture starts some distance from the wound edge, passes deeply under the wound and emerges on the opposite side at the some distance from the edge.
- It then returns by taking a more superficial bite from each wound edge.
- Finally, it consists of a deep suture that involves the skin and the subcutaneous layer (this closes the wound) and of a superficial back stitch placed into the wound edge (this approximates the skin edges).
- The two stitches are in a vertical plane perpendicular to the wound line.

Under the "Interrupted wound closure" click on the menu point of the "Removing sutures" which demonstrates step-by-step how you remove sutures using scissors.

- Grasp the knot with forceps, then cut the suture precisely, just below the knot with a sharp-pointed scissors.
- Remove the suture by pulling back towards the wound so that the wound edges are not drawn apart by a distracting force.
Section 3.

Subcuticular continuous suture

Under the main “Suturing techniques”, click on the menu point of the “Continuous wound closure”, two submenu points of which (“Inserting the suture” and “Completing the closure”) demonstrate step-by-step how to make a single subcuticular continuous suture.

- Guide the needle through the skin, a short distance from the end of the wound (approx. 1 cm). It should come out in the subcuticular plane.
- Grasp the free end of the thread with artery forceps or fix it by a knot.
- Take a bite in the subcuticular plane at right angles to the skin. Allow the needle to follow its own curve. This bite runs parallel to the surface of the skin.
- Readjust the needle so that it points in the opposite direction. Start the next bite exactly opposite the point where the previous one came out.
- Repeat this process with a series of looping bites, all in the subcuticular layer.
- Leave the suture loose as your closure progresses, the wound edges will be separated.
- When you reach the end of the wound, bring the needle out through the skin a short distance from the wound (approx. 1 cm).
- Gently pull the ends of the suture. The wound should close neatly and remain closed when you let go.
- Secure the suture ends by a loose knot or by using adhesive strips.

Section 4.

Wound closure in separate layers with continuous and interrupted sutures

Site: Students’ operating room (OR).

Themes: The topics covered include handling instruments, tying knots, interrupted sutures, simple suture, vertical mattress suture, and continuous suture.

Items needed: Natural animal tissue, curved dissection scissors, toothed forceps, scalpel handle, scalpel blades, needle holder, suture scissors, curved artery forceps and suture material.

Suture of deeper tissues (e.g. muscle, fascia, peritoneum) with continuous suture

Steps

- Grasp and stabilize wound edge with tissue forceps on the far side.
- Starting from the far end of the incision, insert the needle through the tissue.
- The needle is inserted between 0.5–1 cm from the edge, close beside the forceps. The stitch is continued on the other side. The needle should exit the other edge at the same distance (0.5–1 cm) from the wound.
- Only a part of the thread is pulled through and the strands of the opposite sides are knotted.
- Insert the needle again into the far side, make suturing by taking small bites alternately on one side and then the other.
- During suturing, the assistant should continuously hold and guide the thread (with hands or forceps) to prevent it from becoming loose.
- This process is repeated several times alongside the incision until reaching the end. The tension is distributed equally along the length of the suture.
- A knot is tied at the end of the suture so that a part of the thread is pulled through as a simple strand and a double strand remains on the other side.
- The strands of the opposite sides are knotted.

Suture of the subcutis with interrupted suture

Steps

Items needed: absorbable threads (30–35 cm), needle holder, curved 1/2 circle cutting needle.

- The subcutaneous tissue must be stabilized by gently grasping it with tissue forceps 0.5 cm deep on the far side of the wound. The surgeon inserts the needle toward him/her, obliquely downward, 1–2 cm deep.
- Suturing is started with the hand pronated, and the needle is driven following its curvature by progressively supinating the hand until the point of the needle appears.
- The needle exits the tissue perpendicular to the wound. With deep stitches, it can occur that the needle should be released and regrasped. The surgeon must always see the point of the needle if possible.
- When the point of the needle exits the tissue, the needle should be grasped and stabilized with the forceps, then released and regrasped with the needle holder under the forceps and removed from the tissues. The point of the needle must never be grasped with the tissue forceps.
- The free end of the thread is held by the assistant, and its other end is pulled out from the needle by him/her. The assistant ties the knots.
- The needle closed in the jaws of the needle holder is passed to the scrub nurse.
- The distance from one stitch to the next should be approximately 1–1.5 cm. The elevation of tissues with tied knots by the assistant may provide help for the insertion of the next stitch.
- All the stitches are cut just above the knots, but only after the last one has been tied.

Skin suture

For in vitro training and nonhuman practice, #40 linen thread or nylon thread and a skin needle (a 3/8 or 1/4 cutting needle) are used. Donati stitches are used most often for skin closure. It is a 2-row suture: a simple interrupted stitch is placed wide and deep into the wound edge, and a second, more superficial interrupted stitch is placed closer to the wound edge and in the opposite direction. Finally, it consists of a deep suture that involves the skin and the subcutaneous layer (this closes the...
The wound edge is grasped and stabilized with tissue forceps on the far side, and the needle is inserted – 1 cm from the edge, close beside the forceps.

The stitch is continued on the other side. The needle should exit the other skin edge at the same distance (1 cm) from the wound.

The needle is removed from the skin and the point is turned into the opposite direction to make a back-handed stitch (the inner curvature and the point of the needle are up).

The needle is grasped with the needle holder again. During these steps, the position of the needle holder remains unchanged.

The closer wound edge is elevated with the tissue forceps, and a back-handed stitch is inserted 1–2 mm from the edge. The needle should leave the tissues between the cutis and subcutis.

The stitch is repeated in the far side wound edge, from inside to outside.

The thread is removed from the needle. The stitches should be tied just tight enough to approximate the edges without causing ischemia (taking into account that edema will occur during the next few days).

The threads are cut after complete closure of the wound, but – 0.5–1 cm is left above the knots.

The wound should be disinfected with povidone-iodine or iodine tincture and covered with a bandage.

### Section 5.

**Wound closure with metal clips**

Metal clips made of stainless steel or titanium can also be used for the approximation of tissues. In the case of skin, they can be used on fields without wound tension and where wounds tend to heal quickly (e.g. after appendectomy, strumectomy or hernia repairs). Clips fit into the jaws of a special grasping instrument designed for their handling, i.e. the Michel clip applicator and remover.

- The clip is grasped with the forceps-like part of the applicator.
- The assistant approximates and lifts up the opposite wound edges with two tissue forceps.
- The surgeon inserts the clip with the applicator between the two tissue forceps, perpendicular to the incision, with a definite movement.

- When compressed, the toothed tips of the clip are closed with the instrument. The distance between the clips is 1–1.5 cm.
- Clips are removed with the other end of the instrument.

### Evaluation

The suturing skills of the students are assessed by using the following checklist which consists of 18 task steps (instructions to candidates: suture the clean incised wound with interrupted sutures).

<table>
<thead>
<tr>
<th>Item</th>
<th>Done correctly</th>
<th>Not done correctly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Selects appropriate suture, needle holder and forceps</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2. Needle loaded 1/2 to 2/3 from tip</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3. Bite distance from the skin edge: 5 mm</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4. Angle at which bite is taken: 90°</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5. Single attempt while taking bites in the skin</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6. Movement occurs at wrist</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7. Suture board moves or not</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>8. Forceps used to hold skin or sc. tissues (minimum use)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>9. Takes bites from both skin edges in one go/separately</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>10. Equal bites on both sides</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>11. Whether needle is touched with hand</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>12. Number of knots taken</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>13. Knot is square or not</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>14. Knot is too tight or too loose</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>15. Inter-sutural distance: 0.5 to 1 cm</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>16. Knot is on the incision line or on one side</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>17. Skin edges are everted or inverted</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>18. Suture breaks or not</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Maximum total score (18)
A5. MODULE

Basic surgical skills

Learning objectives/aims: This course introduces the simplest surgical methods to help the students to make the first steps in surgery. The program starts with scalpel selection (i.e. appropriate type and size) and its adequate use to make an optimal incision. The roles of surgeon and other team members are explored with special emphasis on the maintenance of asepsis and the handling of different types of bleeding. Students are given the opportunity to change their position and function around the operating table.

Site: Student’s operating room (OR)

Themes: How to make a skin incision, practice of handling surgical bleedings, how to stop oozing or how to apply ligation if larger vessels are bleeding. Methods of drainage are practiced.

Procedures
1. Skin incision
2. Handling bleedings
3. Drainage

Section 1.
Performing a surgical skin incision

Steps
- Plan the direction of the incision.
- Select the optimal scalpel (e.g. #20 blade, #4 handle).
- Place sterile wound towels on both sides of the planned incision.
- Stretch the skin with equal forces on both sides.
- Move the scalpel perpendicularly to the skin. Insert the tip perpendicularly and cut in 45° angle with the edge (and not with the tip).
- Make a single cut, parallel to Langer’s lines, toward oneself, from left to right. The depth of the wound must be the same in the whole length.
- Finish the incision with holding the scalpel perpendicularly.
- Discard the scalpel into the container.

Section 2.
Handling surgical bleedings

- Oozing: apply pressure (i.e. tamponade) with dry or wet (warm saline) sponges. Do not rub, held the sponge on the oozing field for some seconds, then remove it. Alternatively, apply chemical hemostatic agents (Spongostan, Surgicel, etc.).
- Application of electrocoagulation in case of smaller vessels: grasping the bleeding point with a forceps and contact it with diathermy pencil.
- Larger vessels:
  - Soak up blood with a sponge (assistant).
  - Clamp the bleeding with an artery forceps (mosquito, Péan, etc.).
  - Ligature with threads. Tie the first „half-hitch” under the tip of hemostatic forceps.
  - Remove the artery forceps.
  - Tie the second knot.
- Preventive hemostasis:
  - Use an artery forceps to occlude the vessel proximally.
  - Use another forceps to occlude the vessel distally.
  - Cut the vessel between the two forceps.
  - Ligate both ends.

Section 3.
Drainage

Drains are used to channel air/existing fluids (pus, blood, body secretions) from the deeper layers of a wound or a cavity. The major aims of this intervention are alleviation of pain and decreasing inflammation. Using passive drainage the track can be kept open with corrugated sheet drains made of rubber or plastic. Tube drains are supplied with multiple holes, made of silicone, rubber or latex. These also should be secured in place by sutures.

Drainage in practice
- Create an aperture separate from the wound.
- Lay a tube drain into the deepest layer of the wound.
- Grasp the end of tube drain with a clamp and pull it out from the wound through the aperture.
- Close the aperture with a skin stitch and use a loose knot to securing the tube.

Evaluation

Section 1.

The student is able to perform the whole procedure in the right order and sterile technique is maintained during surgical procedures (10 points). Typical mistakes (minus 2 points/mistake):

- Sterility is broken:
  - Student contacts with a nonsterile item (first occurrence minus 2 points, second one minus 4 points, and each additional offense minus 2 points).
  - Absence of sterile wound towels for isolation of the incision.
- Incorrect use of scalpel:
  - The direction of incision is not proper (minus 2 points).
  - The depth of the incision is not uniform in the entire length (minus 2 points).
Section 2.

The student is able to perform the whole procedure in the right order and sterile technique is maintained during surgical procedures (20 points). Typical mistakes (minus 2 points/mistake):

- Rubbing the oozing field with sponge instead of tamponade (minus 2 points).
- Improper electrocoagulation (direct use of diathermy pencil instead of touching to the handle of a grasping instrument) (minus 2 points).
- Improper ligature in case of larger vessels:
  - Student does not use sponge before clamping the bleeding vessel (minus 2 points)
  - Ligature (first „half-hitch”) is too loose (minus 2 points).
  - Clamp is not removed before completion of the knot (minus 2 points)

Section 3.

The student is able to perform the whole procedure in the right order and sterile technique is maintained during surgical procedures (10 points). Typical mistakes (minus 2 points/mistake):

- The position of the aperture is improper (too near or far away from the wound edge) (minus 2 points).
- Drainage is incorrect (pull from outside) (minus 2 points).
- Drain tube is secured to the skin too tightly (minus 2 points).
A6. MODULE

Wound skills

Learning objectives/aims: To update students knowledge of dressing choices, postoperative wound managements and suture removal. Sterile bandage replacement, suture removal, open wound management and bandaging are practiced.

Site: Students’ operating room (OR)

Themes: Wound management and bandaging

Procedures:
1. Suture removal and sterile bandage replacement
2. Open wound management
3. Covering bandages
4. Steam bandage
5. Compression bandage
6. Fixing/retention bandage

Section 3.

Covering bandage

Main types of bandages are adherent/taped, covering (steam bandage), pressing, wedging, compressing and fixing/retention. Covering bandages are used for temporary protection of accidental wounds and to cover surgical wounds.

Materials needed: sterile forceps, sterile syringes, sponges and bandages.

Steps
- Placement of layer in direct contact with the wound (mull sheets, impregnated sheets)
- Absorbent layer (to absorb and store blood and excretions; more layers of gauze)
- Fixing layer (to fix bandage, adherent tapes)

Section 4.

Steam bandage

It is used for localization of a purulent process and facilitation of pus discharge towards the surface.

Steps/layers
- Ointment (e.g. Burow ointment, which aids demarcation of the necrotic area) is applied.
- Sterile gauze sheet is applied.
- Plastic layer (for isolation of heat and steam)
- Fixing layer

Section 5.

Compression bandage

It is used to prevent postoperative bleeding (e.g. on the limbs), for thrombosis prophylaxis and reduction of chronic lymphedema. It is always placed from distal to proximal direction.
Material needed: elastic/ace bandage. A scheme is shown below:

Fig. 1. Compression bandage

Steps
- Starting distally on the limb, elastic bandage is placed horizontally on the extensor side, but obliquely and in alternate direction on the flector side while advancing proximally.
- The bandage is fixed at the end with adhesive strips or clips.

Section 6.
Fixing / retention bandage

It is used to keep injured body parts, e.g. to fix a limb in a resting position after reposition. Here Desault bandage is used for the shoulder (a scheme is shown below):

Fig. 2. Desault bandage

Evaluation

Sections 1–2.
- This student maintained sterile technique during procedure; dressings/procedures were applied correctly (25 points).
- Touched an unsterile item or area, acknowledged occurrence and readily offered a solution to the break in technique (first offense 0 points, second offense minus 5 points, each additional offense minus 5 points).

Sections 3–6.
- Dressings/procedures were applied correctly (20 points).
- Indications for wound management procedure are not known (minus 5 points).
- Steps of wound management procedure are incorrect (minus 5 points)
- Bandage is loose/applied incorrectly (minus 5 points)
“B” MODULES

The “B” course is aimed to teach monitoring skills. In medicine, monitoring may be defined as interpretation of all collected clinical data to help recognize unfavorable system conditions in time. In this sense, the technique and methodology, the “skills” of the analyzer is critical. The themes are organized into modules, and these are taught in the skills laboratory and in the students’ operation theater in simulated, life-like environment, where basic monitoring techniques and advanced interventions targeting the main organ systems can be practiced in a secure surrounding.
**B1. MODULE – INJECTION SKILLS**

### B1. MODULE

**Injection skills**

**Site:** Skills laboratory and students’ operating room.

**Themes:** Basic injection techniques (ic., sc., im., iv.); use of “butterfly” needle and braunule; blood sampling, administration of infusions; use of infusion pumps. Educating students to administer iv. therapy is a challenging task, but Virtual Reality (VR)-simulated environments allow trainees to repeat procedural experiences at their own leisure. VR is a computer-based, simulated environment in which users interact with a high-performance computer, graphics, specialized software, and devices providing visual, tactile, and auditory feedback, thereby simulating a true-life environment.

**Procedures:**
1. Techniques of ic., sc., im. and iv. injections
2. Injection technique with a “butterfly” needle and braunule
3. Technique of blood sampling
4. Administration of infusions
5. Use of infusion pumps
6. VR training using the iv. therapy trainer (CathSim system)

### Section 1.

**Techniques of ic., sc., im. and iv. injections**

**Aim:** Administration of drugs, vaccines, fluids etc. Understanding the theory of venipuncture including the anatomical position of superficial veins of the upper limb, the rationale for performing venipuncture, how to select a suitable vein for venipuncture and correct order of sampling and choice of blood tubes.

**Site:** Students’ operating room

**Steps/general rules**
- Before giving injection or taking blood samples, hands should be washed and gloves should be worn to protect ourselves from infections.
- Traditional glass ampoules should be wrapped in thick gauze, and a file cut is made on the neck. Today this is no longer needed as the ampoules have a thinned neck. The end of the ampoule is simply broken off.
- In case of vials with a rubber stop the aluminum shield should be removed, and the rubber stop should be disinfected.
- The needle on the syringe, the opening of the ampoule and the disinfected rubber stop must not touch nonsterile surfaces (e.g. the outside wall of the ampoule, hand) when its content is sucked out. The needle should be changed before injection.
- To prevent air embolism, air must be removed from the syringe and the needle before injection: the syringe with the needle should be held upward, the syringe is shaken to expel air from the liquid, and the plunger is pushed to remove it from the syringe.
- Before injection, the skin area must be carefully disinfected by an alcoholic spray or by scrubbing with a sponge with alcohol. It is necessary to wait for 15–30 s for the effect of disinfection.

#### Iv. injection
- A tuberculin type syringe (1 mℓ) and a short, thin (25–27G) needle are used. This technique is practised on practice pads and/or a piece of pig’s abdominal wall. The needle is inserted at an angle of 10–20°, bevel up, at least 1 cm long into the upper layers of the skin.
- A small volume (0.1–0.2 mℓ) of physiological saline is administered just under the “epidermis”. A vesicle is formed, if the injection has been given into the appropriate layer.
- A sterile sponge is pressed on the site of the puncture, and the needle is then removed from the skin.

#### Sc. injection
- A 1–2 mℓ syringe with a thin (25–27G) needle is used.
- This technique is practised on practice pads and/or a piece of pig’s abdominal wall. The injection is given into the fat and connective tissue underlying the skin.
- The skin should be pinched into a fold to elevate the sc. adipose tissue away from the underlying muscle layer. The injection is given at an angle of about 45° into the raised skin fold.
- The plunger should be drawn back to check whether blood is coming back into the syringe.
- The injection can be given only if no blood appears (i.e. it is not administered iv.)
- A sterile sponge is pressed onto the site of the injection, and the needle is then removed. The sponge is pushed on the puncture site for some minutes to prevent bleeding.

#### Im. injection
- This is used for the injection of a larger volume (max. 5 mℓ) into the muscular tissue. A needle of 20–25G should be selected.
- This technique is practised on practice pads and/or a piece of pig’s abdominal wall. The skin over the injection site should be stretched gently between the thumb and index finger by using the Z-track technique which prevents the leakage of the injected fluid. The needle is then inserted at an angle of 90°.
- The injection can be started only when no blood can be drawn back into the syringe.
- The needle is pulled out and a sterile sponge is pressed on the site of the injection to prevent bleeding.

#### Iv. injection
- This is first practised on a phantom hand. In this case, the sites for the injection are the dorsal “veins” of the hand. A tourniquet is used centrally to the vein “to make the vein bulge”.
- 18–23G hypodermic needles are used.
- The skin should be stretched above the vein in the opposite direction to the puncture so that it does not move during puncturing.
The syringe with the needle is grasped with the thumb and index finger, and it is supported with the middle finger. The vein must be punctured with the bevel up at an angle of 30–45° in the direction of the vessel. When the needle is in place, blood is drawn to check whether the needle is in the vein. If it is, the needle is then advanced about 1 cm at a decreased angle in the lumen of the vein.

The tourniquet is then released, and the injection is slowly given into the bloodstream.

A sterile sponge is pressed on the site of the injection, the needle is pulled out and the patient’s elbow should be kept in a flexed position.

Section 2.

Technique of injection with a “butterfly” needle or braunule

**Aims:** Securing veins for collecting blood samples, administering drugs, infusion therapy, etc. This technique is also practised on a phantom hand. In this case, the sites for the injection are the dorsal “veins” of the hand.

- The “butterfly” needle is grasped with the thumb and index finger. The injection port of the braunule is grasped with the index and middle fingers while the stopper is held with the thumb and the fourth and fifth fingers are placed on the patient's skin.
- The needle or catheter is pushed slowly into the vein at an angle of 30–45° until some “blood” (red ink) appears at the end of the needle or in the blood chamber of the injection port of the braunule. The skin, sc. connective tissue, and the wall of the vessel should be penetrated with one continuous movement. The needle or catheter is then advanced about 1 cm at a decreased angle in the lumen of the vein.
- Above the end of the catheter, the vein is pressed down with the ring finger while the needle is drawn back about 1 cm. The appearance of “blood” in the plastic catheter indicates that it is positioned in the vessel lumen. The catheter is pushed forward into the vein lumen. During the introduction, the needle prevents the inclination of the plastic catheter while the drawing-back of the needle prevents damaging of the vessel wall.
- A sponge is placed under the end of the braunule. The tip of the catheter is touched and pressed gently by the left index finger. The catheter is held with the thumb and index finger while the needle is removed with the other hand.
- The catheter is closed with a cap or connected to an infusion set. The tourniquet is released.
- The needle or catheter should be fixed to the patient’s skin with adhesive tapes so as not to be pulled out or broken when the patient moves the arm. Adhesive tape fixed to the injection port provides protection against contamination.
- Removing the “butterfly” needle or braunule: An alcoholic sponge is pressed onto the site of the puncture and it is then pushed while the needle or braunule is removed. The alcoholic sponge should be pressed on the puncture site until the “bleeding” has stopped.

Section 3.

Technique of blood sampling

**Aim:** Collecting blood samples for laboratory analysis in the correct order and place in correct blood tubes

- The needle of a blood sampling syringe is introduced into the vein and removed as described above.
- The needle is fixed with one hand, while the blood sampling tubes are changed with the other hand.
- The sequence of sampling: serum tube (white); 2. coagulation tube (green); 3. sedimentation tube (purple); hematocrit (red) tubes; etc. The coagulation, sedimentation and hematocrit tubes should be filled exactly to achieve the correct dilution. Tubes should be shaken gently to mix the sample with the anticoagulant.

Section 4.

Administration of infusions

**Aims:** Administration of a major volume of fluid, electrolytes and drug into the circulation by which a longer period of administration and a constant concentration of drugs in the blood can be achieved.

- The sterile infusion set is wrapped in a double package (plastic and paper). The package is opened just before use. Parts of the set: a spike, a drip chamber and long tubing with the flow regulator.
- The protective covering is removed from the port of the infusion bag and from the spike, and the spike is inserted into the port of the bag.
- The bag is hung on the infusion stand. The lower part of the drip chamber squeezed to set the fluid level, until the drip chamber is approximately one-third full. If the level is too low, the chamber is squeezed to remove air to the bag. If the chamber is overfilled, the bag is lowered to below the level of the drip chamber, and some fluid is squeezed back into the bag.
- The flow regulator is opened, and the fluid is allowed to flow into the tubing. Air should be expelled from the tubing.
- The end of the tubing is connected to the iv. needle or catheter in the patient’s vein, and the flow rate is adjusted as desired.
- A loop is made in the tubing and secured to the patient’s skin with strips of adhesive tape.
- At the end of the infusion, the flow regulator is closed, the tapes are removed, and the tubing is disconnect- ed from the needle or catheter. If securing of a vein is no longer needed, the needle or braunule should also be removed, and the site of the puncture is covered with a sterile gauze.
Section 5.
Use of infusion pumps

**Aims:** Accurate, continuous, long-term and slow delivery of infusions and medication, enteral feeding products to reach a constant blood level during therapy. Main types: volumetric and syringe infusion pumps
- The infusion pump is shut on.
- The syringe is placed into the apparatus.
- The volume infused and the flow rate is preset.
- The operation is started.
- The infusion pump is shut off, and the syringe is removed.

Section 6.
Virtual reality (VR)

Training with a simulator, incorporated into an individual or small group learning session, offers a means to learn and realistically practice endovascular procedures without direct risk to patients, with measurable improvements in key performance metrics. This program provides a step-by-step training guide for iv. therapy and long-term catheter care. Students participate in a series of vascular training programs that use a high-fidelity endovascular procedure simulator, didactic instruction, computer-based training, and tabletop procedure demonstrations.

Evaluation

Section 1.

The student should keep the general rules of giving injections (5 points), and he/she should perform an ic. (5 points), a sc. (5 points), and an iv. injection (5 points) as described (total: 25 points). Typical errors (minus 1 point each):
- **General rules:** hand wash and/or gowning is not performed; asepsis is not maintained (rubber stop of the vial or skin is not disinfected properly; the sterility of the syringe and needle is broken etc.); the needle is not changed after the suction of the drug; air is not removed from the syringe.

Section 2.

The student should unwrap the needle or braunule set, and he/she should introduce the needle or catheter observing the rules of asepsis during the entire procedure (10 points). Typical errors (minus 1 point each):
- Hand wash and/or gowning is not performed; mistakes in maintaining asepsis (the injection site is not disinfected properly, sterility of the devices is broken, etc.); the technique of the injection/cannulation or the removal of the needle/catheter is not correct; the needle/cannula is not introduced iv. or punctures the posterior wall of the vein; the site of the needle/braunule is not controlled after introduction; the needle/cannula is not fixed; no tamponade with an alcoholic sponge is used after removal.

Section 3.

The student should imitate blood sampling on the phantom hand after the needle/catheter has been introduced iv. (5 points). Typical errors (minus 1 point each):
- Sterility is broken; the needle is not fixed with one hand during the procedure; the tubes are changed in incorrect sequence; the dilution of the samples is not correct; the samples are not mixed with the anticoagulant.

Section 4.

The student should unwrap, assemble and connect the infusion set to the iv. catheter under aseptic conditions, and he/she should adjust the flow rate (5 points). Typical errors (minus 1 point each):
- Sterility is broken during the procedure; the set is improperly assembled; the fluid level in the drip chamber is too low or high; the air is not expelled from the tubing; the flow rate is not adjusted; the tubing is not fixed.
B2. MODULE

Cannulation skills

Learning objectives/aims: This practical session provides the students a safe environment with ex vivo tissues. Each student will be able to decide the size/type of device to be used, choose an appropriate insertion site, prepare the appropriate equipment, complete the procedure safely and conclude the care episode.

The first task is percutaneous puncture of a central vein by Seldinger technique. The following set is required: 16G braunule, flexible guide-wire (60 cm), dilator (8F × 12 cm), a single lumen catheter (7F × 20 cm).

The second task is venous cut-down, i.e. a surgical exposure of a vein. It is necessary if it is impossible to insert a needle or cannula into a satisfactory vein, or the percutaneous insertion of the vena cava catheter (i.e. Seldinger technique) is contraindicated. This procedure is practised ex vivo, on a phantom using a model prepared from pig’s abdominal wall. In this case plastic tubes represent the veins. Students are working in operating teams: roles include surgeon, first assistant, and scrub nurse.

Procedures:
1. Seldinger technique
2. Venous cut-down

Section 1.

Percutaneous puncture of a central vein by Seldinger technique

Steps
- During this intervention an aseptic technique should be applied. The operative field is scrubbed as usual. A sterile drape with a small round hole is used for the isolation the wound site.
- Following the localization of the peripheral vein, insert a 16G braunule needle into the vein at an angle of 30–45°.
- Pull back the needle slowly until some “blood” (red ink) appears at the cannula or in the blood chamber of the injection port of the braunule.
- Introduce the cannula into the vein and simultaneously remove the needle.
- Insert a flexible guide-wire into the cannula and introduce it into the lumen of the central vein until collision.
- Remove the braunule cannula through the flexible guide-wire.
- Introduce—then remove the dilator cannula through the flexible guide-wire (if it is needed).
- Introduce a single lumen catheter through the guide-wire into the central vein.
- Remove the guide-wire.
- Fix the catheter securely.
Section 2.

Venous cut-down

Steps
- During venous cut-down, an aseptic technique should be applied. The operative field is scrubbed as usual. A sterile drape with a small round hole is used for the isolation of the wound site.
- The skin is fixed and stretched by the thumb and index finger of the surgeon’s left hand.
- A longitudinal skin incision is performed which follows the line of the vessels. The skin should be cut in a straight line with a single incision and the depth of the wound must be equal everywhere.
- Handling bleeding is practised.
- Dissection of vein: The subcutaneous connective tissues are divided with Mayo scissors using blunt and sharp dissections. The superficial layer of the subcutis is grasped and lifted up with two tissue forceps by the surgeon and the first assistant.
- A small cut is made with the scissors between the two forceps. The scissors are inserted with closed blades into the hole where they are opened. The blunt, outer edges of the blades separate the tissues (blunt dissection). The opened scissors are then pulled out from the wound, and, following the line of the dissection, the tissues are cut in both directions to reach the wound corners.
- By repeating the process, the deeper layers are separated step-by-step. The preparation is always done parallel to the “vessel”. To prevent inadvertent injuries, tissue forceps are replaced by dressing forceps in the proximity of the “vessel”, and only blunt dissection is used to separate the “vein” from the surrounding tissues.
- A doubled #40 linen thread is clamped at the middle with a mosquito hemostat. This is placed beneath the “vein” and both strands are pulled through.
- The thread is then released and cut into two parts, and one of them is drawn “distally”, the other “proximally”. The distal thread is firmly tied by the surgeon.
- A loose half-hitch is made on the proximal thread by the assistant, and the “vein” is stretched between the two ligatures.
- The assistant grasps and picks up the “vessel” wall with dental forceps about 5 mm from the distal knot.
- Using fine scissors, a V-shaped incision is made by the surgeon in the vein. The incision should involve one third of the lumen.
- A dental forceps is placed into the hole to expose the lumen of the “vein”.
- The cannula is inserted and the forceps are removed.
- The cannula is passed beyond the loose proximal half-hitch while it is pulled down with the forceps. The catheter is then carefully introduced. If it meets a resistance, it should be withdrawn and advanced again while moving it sideways trying to find the right passageway.
- After the cannula has been introduced, the loose half-hitch should be tightened and a second half hitch is tied. Care should be taken not to close the lumen of the cannula.
- Finally, the cannula is also secured by the distal ligature, and the threads are cut short.
- In the event of in vivo exposure and cannulation of veins, the surgeon should check whether the cannula is functioning. For this reason, a small volume of physiological saline is injected into the vein, then blood is drawn back into the syringe.
- Removal of the intravenous cannula: A thread is first passed around the vein with a mosquito hemostat beyond the proximal knot and a loose half hitch is tied. The distal and proximal ties securing the cannula are picked up with dressing forceps, they are cut beneath the knots and removed. The cannula is withdrawn slowly. When its end appears in the opening of the vein, the loose half hitch is tightened and a second half hitch is tied. The threads are cut short.
- Closure of the wound: A standard wound closure is made in two steps. First, the subcutaneous tissues are sutured with interrupted stitches using #60 or #80 linen thread and half-circle cutting needles. The skin wound is closed with Donati-type vertical mattress sutures using #40 linen thread and 1/4 or 3/8 cutting needles. Finally, the wound is painted with povidone-iodine and covered by a bandage.

Evaluation

Sections 1–2.
- The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (20 points).
- Typical mistakes (minus 2 points/mistake): sterility is broken; the direction and depth of puncture is not proper, improper grasping of the braunule, impossible to introduce the flexible guide-wire into the cannula, catheter fixation is not proper because the ligature is too loose, etc.
- See B3.1. MODULE.
B3/1. MODULE

Advanced cannulation skills 1.

Learning objectives/aims: To understand the indications for central venous catheter placement, to understand the contraindications to central venous catheter placement, to become familiar with the supplies and setup required for successful line placement, to become adept at identifying anatomic landmarks for the insertion sites, to become familiar with the complications of central line placement. These procedures are performed on anesthetized minipigs.

Site: Students’ operating room (OR)

Themes: Cannulation and complex in vivo monitoring of the cardiovascular system using aseptic techniques.

Procedures:
1. Cannulation of the jugular vein
2. Central venous pressure (CVP) measurement

Section 1.

Cannulation of the jugular vein

The operative area is the left side of the neck of the pig. The site should be disinfected and draped as usual. The following instruments are required: scalpel, diathermy pencil, Mayo scissors, Péan forceps (mosquitos), dissector, dental forceps, thread, needles and needle holder, sterile sponges.

Steps
- Stretch the skin on both sides of the planned incision.
- Make a 5–7 cm long skin incision parallel to the vein with a skin scalpel (Fig. 1).
- Dissection of subcutaneous tissues with diathermy pencil
- Handle bleeding if necessary.
- Localisation of the vein (usually in approx. 2 cm depth)
- Place the closed blades of the scissors next to the vessels and dissect it free by careful blunt preparation (Fig. 2).
- When a 2–3 cm part is freed, introduce a double thread under the vessel with mosquito forceps or a dissector and divide it into two parts (Fig. 3–4).
- Make loose half-hitches on the proximal and distal threads under the vein.
- Open the vessel with vascular (or iris) scissors (Fig. 5).
- Explore the lumen of the vein with introducing a dental forceps (Fig. 6).
- Introduce a saline-filled central venous (CV) catheter closed with 3-way stopcock into the lumen between the blades of dental forceps (Fig. 7).
- The catheter should be fixed by tightening both half-hitches (proximal and distal) and tying the second knots (Fig. 8).
- Close the wound with subcutaneous and vertical mattress sutures.

Fig. 1. Skin incision
Fig. 2. Blunt dissection
Fig. 3. Introducing a double thread under the vessel
Fig. 4. Dividing the thread
Fig. 5. Opening the vessel with iris scissors
Fig. 6. Exploring the lumen with a dental forceps
Fig. 7. Introducing a catheter
Fig. 8. Fixing the catheter

Section 2.

CVP measurement

The following instruments are needed: pressure sensor transducer, connecting tube (between the CVP catheter and pressure sensor), sterile normal saline to rinse the catheter (with 100 U/ml heparin), computerized data-acquisition system (i.e. hemodynamic monitor).

Steps
- Connect the CVP catheter to the pressure sensor transducer and fill it up with saline. The catheter must be bubble-free.
- Fix the transducer at the heart level.
- Set zero level of the transducer by turning the 3-way stopcock to “air”.
- Set up the computerized data-acquisition system for pressure measurement.
Open the 3-way stopcock toward the CVP catheter (closed to air) and start the measurement.

Fig. 9. Position of the CVP catheter in the left jugular vein.

Evaluation

The students (in surgeon’s, assistant’s and scrub nurse’s role) should perform scrub preparation of their hands, gowning and gloving, scrub preparation and draping of the operative field, surgical exposure and cannulation of a vein, removal of the catheter and wound closure under aseptic conditions (40 points in each role). Students should be able to work in each role.

Typical errors (minus 1 point each):

- Errors in aseptic technique: unrecognized, uncorrected mistakes in the following:
  - putting on caps, masks, shoe covers;
  - mechanical scrub preparation and disinfection of hands;
  - gowning and gloving;
  - behaviour and movement in the operating room;
  - scrub preparation and draping of the surgical area;
  - maintaining asepsis during operation.

- Errors in surgical technique:
  - incorrect position at the operating table;
  - use of inadequate instruments (e.g. dressing forceps for grasping skin, tissue forceps for grasping “vessels”, general purpose scissors instead of Mayo scissors for blunt dissection, etc.) or inappropriate materials (e.g. 1/4 needles for suturing sc. tissue, thin threads for fixing the catheter to the “vein”, etc.);
  - incorrect handling and passing of instruments;
  - errors in tying knots (e.g. no square knots are tied; knots are too loose or too tight, etc.);
  - errors in skin incision (e.g. skin is not stabilized; cutting is too long, too short, too superficial or too deep; several parallel superficial incisions are made, etc.);
  - errors in dividing sc. tissue (e.g. scalpel is used instead of Mayo scissors; cutting with scissors instead of blunt dissection, especially in the proximity of the “vein”, etc.);
  - bleeding is not handled adequately;
  - errors in the preparation and cannulation of the “vein” (it is not separated or cleaned properly from the surrounding connective tissue, the length of the dissected section of the “vein” is too short, it is severed, cut or torn; a single thread is passed beneath it instead of a double one; the distal ligature is not tightened, the proximal ligature closes the lumen of the “vein”, the incision in the “vessel” is too close to the distal ligature, too small or too big, the cannula is introduced into the “vein” too shortly or to the adventitia instead of the lumen; the right passage way of the catheter is not found; the ligature securing the cannula is too loose or too tight; it is not checked whether the catheter is functioning, etc.);
  - errors during the removal of the catheter (e.g. no thread is passed around the vein before removing the proximal ligature; the distal ligature is removed; the new proximal ligature is knotted before removing the cannula, etc.);
  - errors in wound closure (e.g. the sc. layer is not closed or it is sewn with too thick thread; the skin stitches are not placed properly; the wound edges are everted or inverted; the knots are tightened very much, the wound is not disinfected, etc.)

- CVP measurement is false because:
  - there are bubbles in the measurement setting;
  - the position of the sensor is not appropriate.

- There is no pulsatile signal on the monitor because:
  - the direction of 3-way stopcock is not proper;
  - the catheter is occluded by clotted blood.
B3/2. MODULE

Complex hemodynamic monitoring. Advanced cannulation skills 2.

Procedures:
1. Cannulation of the femoral artery
2. Arterial pressure measurement
3. Dissection of carotid artery
4. Blood flow measurement
5. Positioning of a Swan-Ganz catheter in the pulmonary artery
6. Cardiac output measurement by thermodilution method

Section 1.

Cannulation of the femoral artery

The operative area is the left inguinal region. The site should be disinfected and draped as usual. The following instruments are required: scalpel, diathermy pencil, Mayo scissors, Péan hemostat (mosquito), dissector, plain retractor, dental forceps, thread, needles and needle holder, sterile sponges.

Steps
- Stretch the skin on both sides of the planned incision.
- Make a skin incision (5–7 cm) perpendicular to the arterial bed using a skin scalpel.
- Dissect the subcutaneous tissues with diathermy pencil.
- Handle bleeding if necessary.
- Use retractors to lift the abdominal wall which covers the arterial bed.
- Localize the femoral artery (it runs together with the femoral vein) deeply in the inguinal region.
- Place the closed blades of the scissors next to the vessels and dissect free the artery by using careful blunt preparation.
- Use dressing forceps only to grasp the surrounding tissue.
- When approx. 1.5–2 cm part of the artery is freed, introduce a double thread under the vessel with mosquito hemostat or dissector and divide it into two parts.
- Make a loose half hitch on proximal side.
- Fix the transducer at the heart level.
- Set zero level of the transducer by turning the 3-way stopcock to air.
- Set up computerized data-acquisition system to pressure measurement.
- Open the 3-way stopcock to artery catheter (closed to air) and start the measurement.

Fig. 10. Position of a thermistor-pressure sensor catheter in the left femoral artery.

Section 3.

Dissection of the carotid artery

The operative area is the right side of the neck. The site should be disinfected and draped as usual. The following instruments are required: scalpel, diathermy pencil, Mayo scissors, Péan hemostat (mosquito), dissector, plain retractor, thread, needles and needle holder, sterile sponges, vessel loops.

Steps
- Stretch the skin on both sides of the planned incision.
- Make skin incision (5–7 cm) parallel to the artery bed with a skin scalpel.
- Dissect the subcutaneous tissues with diathermy pencil.
- Handle bleeding if necessary.
- Retract the sternocleidomastoideus muscle which covers the carotid artery bed.
- Localize the pulsing carotid artery (together with the vagal nerve) in approx. 2 cm depth.
- Place the closed blades of the scissors or dissector next to the vessels and dissect free the artery by careful blunt preparation.
- Use dressing forceps only to grasp the surrounding tissue.
When a 2–3 cm section of the artery is free, introduce a vessel loop under the artery with mosquito hemostat.

**Section 4.**

**Measurement of carotid artery blood flow**

The following instruments are required: dissector, plain retractor, sterile sponges, flowmeter (here a Transonic 2T Research Flowmeter is used), perivascular flow probe, ultrasound gel.

**Steps**
- Take a perivascular flow probe of appropriate size and place it around the carotid artery.
- Connect it to a flowmeter.
- Put ultrasound gel around the flow probe to achieve good contact and signals.
- Following several seconds the display of flowmeter will show the actual value of the arterial blood flow.

![Blood flow probe around the left carotid artery](image1)

**Fig. 11.** Position of the perivascular blood flow probe on the left carotid artery.

**Section 5.**

**Positioning a Swan-Ganz catheter into the pulmonary artery**

The operative area is the right side of the neck, the site should be disinfected and draped as usual. The following instruments are required: scalpel, diathermy pencil, Mayo scissors, Péan hemostats (mosquito), dissector, dental forceps, thread, needles and needle holder, sterile sponges, Swan-Ganz catheter. This special catheter has four lumina. The yellow branch is used to monitor pressure signals (the right atrial pressure, the right ventricular pressure, the pulmonary artery pressure and the pulmonary capillary wedge pressure). The blue branch is used to inject the thermal bolus into the right atrium for thermodilution cardiac output measurements or to monitor CVP. The end of the blue lumen is located 29 cm from the tip of catheter. The red channel provides means of inflating and deflating the balloon located near to the tip of the catheter. The inflated balloon permits the catheter tip to be driven into the pulmonary artery. The white cable (thermistor cable) provides an electrical connection to the temperature-sensitive thermistor head. It is located 3 cm from the tip of the catheter and is used to measure the blood temperature. The catheter is introduced into the pulmonary artery with continuous monitoring of the pressure signal and using the inflatable balloon at the tip of catheter.

**Steps**
- Surgical exposure of the right jugular vein. The method and steps are the same as in case of the left jugular vein (see B3/1. Module).
- A Swan-Ganz catheter is introduced through the jugular vein, under continuous pressure control. The catheter is pushed approx. 15–20 cm into the vein.
- When the pressure signal of the right ventricle has been obtained, inflate the balloon at the tip of the catheter balloon through the red lumen with max. 1 mℓ air using a 2-mℓ syringe.
- Push forward the catheter with inflated balloon approx. 5–10 cm, until a 10–25 mm Hg pressure signal can be seen on the monitor. It indicates that the catheter tip is positioned in the pulmonary artery.
- Pulmonary capillary wedge pressure can be measured distally from the catheter tip if the catheter is pushed ahead until collision.
- Never pull back the catheter with inflated balloon.
- The catheter can be closed by clotted blood, therefore it should be rinsed frequently.
- The measurement of the pulmonary artery pressure is identical with the measurement of the peripheral arterial pressure (see Section 2).

![Swan-Ganz catheter](image2)

**Fig. 12.** Introduction of a Swan-Ganz catheter through the right jugular vein into the pulmonary artery.

**Section 6.**

**Cardiac output (CO) measurement**

The following instruments/sets are required: thermistor-pressure sensor catheter in the femoral artery, pressure transducer, connecting tube between the arterial catheter and pressure sensor, CVP catheter with thermosensor for the injection of cold saline, sterile saline of normal temperature for the rinsing of catheters (with 100 U/mℓ heparin), 10 mℓ syringe, cold saline (with 100 U/mℓ heparin) for thermodilution cardiac output measurement, connecting cables between thermosensors (temperature sensor detecting the injected saline, arterial thermosensor) and computer, computerized data-acquisition system (hemodynamic monitor).
Steps

- Switch on the CO computer.
- A known volume of cold saline (10 mℓ) is injected iv., as fast as possible. Saline temperature should be at least 10 °C lower than blood temperature.
- The passage of the heat bolus injected into the central vein is registered by a thermistor catheter positioned in the femoral artery.
- The temperature change recorded downstream depends on the flow and on the volume through which the cold indicator has passed. As a result, a thermodilution curve can be obtained.
- The cardiac output is calculated from the area under the thermodilution curve.

Arterial pressure measurement is false because:
- there are air bubbles in the measurement setting;
- the position of sensor is not appropriate.
- There is no pulsatile signal on the monitor because:
  - the direction of the 3-way stopcock is not proper;
  - the catheter is occluded by clotted blood.

Section 3–4.

The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (20 points). Typical mistakes (minus 2 points/mistake):
- Sterility is broken
- The direction of incision is not proper.
- Unsuccessful handling of bleeding.
- Blunt preparation is too rough.
- Incorrect use of tissue forceps.
- Branches of artery or nervus vagus are injured.
- Arterial blood flow measurement is false because there is not enough ultrasound gel around the flow probe, or the position of sensor is not proper.

Section 5.

The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (10 points). Typical mistakes (minus 2 points/mistake):
- Sterility is broken
- The catheter is occluded by clotted blood, there is no pulsatile signal on the monitor.
- Pulling back the catheter with inflated balloon (!)
- Balloon is inflated with more than 1.5 mℓ air.

Section 6.

Students have to carry out 3 parallel CO measurements which do not differ significantly (5 points). Typical mistakes of measurement (minus 1 points/mistake):
- The venous or arterial catheters are closed by clotted blood.
- The sensors are disconnected from the computer.
- The speed of cold saline injection is too slow.
- The temperature of the injected saline is close to the blood temperature.
B4. MODULE — GASTROINTESTINAL MONITORING SKILLS

B4. MODULE
Gastrointestinal monitoring skills

Site: Students' operating room (OR)

Themes: Indirect determination of gastrointestinal oxygenation in anesthetized animals (pigs). Visualization of the sublingual microcirculation and measurement of intramucosal oxygenization

Items needed: Capillary air tonometer, capnograph, blood gas analyser, syringes, caps to close syringes, heparin. Orthogonal polarization spectral (OPS) system: OPS probe and light source (Cytometrics, USA), videorecorder, monitor

Procedures
1. Measurement of sublingual mucosal pCO₂
2. Measurement of arterial pCO₂
3. Determination of sublingual mucosal-arterial CO₂ gap as the marker of tissue hypoperfusion
4. Intravital video-microscopy with OPS imaging of the sublingual mucosal microcirculation

Section 1.
Measurement of sublingual mucosal pCO₂

Steps
- Place a tonometer catheter under the tongue of the animal, and isolate the mouth with a nylon sheet.
- After approx. 10 min equilibration the pCO₂ of the mucosa will be the same as the pCO₂ of air (as filling medium) in the tonometer.
- Connect the microstream ETCO₂ filter line to the tonometer, and press the pump button to take a small air sample for pCO₂ analysis.
- A capnograph is used to measure pCO₂ of the tonometer.

Section 2.
Measurement of pCO₂ in the arterial blood

- Take an arterial blood sample into a heparinized syringe (see Section 4 of B5. Module).
- Measure the pCO₂ of the sample using a blood gas analyzer.

Section 3.
Determination of sublingual mucosal-arterial CO₂ gap

- CO₂ gap = sublingual pCO₂ - arterial pCO₂. Normal value is under 10 mm Hg.

Section 4.
Intravital microscopy and imaging of the sublingual mucosal microcirculation

Steps
- Adjust and fix the OPS probe on the surface of the mucosa under the tongue of the animal.
- After recording, blood flow velocity, changes in capillary diameter or capillary perfusion ratio can be determined.

Evaluation

- Properly performed measurements/imaging and recording (15 points)
**B5. MODULE**

**Respiratory system monitoring**

**Site:** Students' operating room (OR)

**Themes:** Securing open airways, monitoring of respiratory gases, taking blood samples, measuring blood gas values, using mechanical ventilation in anesthetized animals

**Procedures:**
1. Endotracheal intubation
2. Capnography
3. Pulse-oximetry
4. Taking blood samples
5. Blood gas analysis
6. Mechanical ventilation

**Section 1.**

**Endotracheal intubation**

The endotracheal intubation can be performed in anesthetized animals (pigs) but it can be safely practised in a head model also.

**Steps**
- Preparing the required equipments: endotracheal tube, laryngoscope, syringe for inflation of the cuff, Guedel tube (bite block), adhesive tape, head model, a Péan hemostat for clamping the duct of the cuff, tape or Köpper band for fixing the tube, suction catheter and pump/syringe to remove mucus.

**Sections 2. and 3.**

**Capnography and pulse-oximetry**

A combined capnograph/pulse-oximeter (Nellcor, USA) apparatus is used to continuously monitor (measure and display) ETCO₂ and respiratory rate, oxygen saturation and pulse rate in the anesthetized animals (pigs).
Section 4. Taking blood samples for blood gas analysis

Materials needed: Sterile syringes (2 or 5 ml), caps to close the syringes, anticoagulant (heparin), sterile gloves. Blood samples can be taken from an arterial, a venous or a central venous (mixed venous blood) catheter.

Steps
- Before sampling a proper amount of anticoagulant (50–100 U/ml blood) is aspirated into the conus of syringe.
- Take and discard 4-times saline/blood of the catheter volume.
- Before sampling a proper amount of anticoagulant (50–100 U/ml blood) is aspirated into the conus of syringe.
- Take and discard 4-times saline/blood of the catheter volume.
- Before sampling a proper amount of anticoagulant (50–100 U/ml blood) is aspirated into the conus of syringe.
- Take and discard 4-times saline/blood of the catheter volume.
- Take blood sample (max. 1 ml) into the heparinized syringe.
- Mix the blood carefully with heparin by rotating the syringe gently up and down to avoid formation of small clots.
- Remove the air bubbles from the syringe, then close the syringe with a cap.
- Flush the catheter with heparinized saline.

Section 5. Blood gas analysis

Blood gas analysis should be done immediately after sampling (if possible) or within at most 10 min. If it is not possible, keep the samples in iced water (0 to 4 °C) for max. 30 minutes.

Steps
- Mix the blood immediately before analysis to avoid sedimentation of cells.
- Before injecting the sample into the analyser, discard the first drops of the blood sample from the syringe.
- The measurement is performed with a blood sample volume of at least 55 µl. The analysis time of a sample is 20 seconds. Measured parameters: pO₂, pCO₂, pH. Calculated parameters: BE (base excess), HCO₃⁻ (actual bicarbonate), cHCO₃⁻ (standard bicarbonate), SaO₂ (oxygen saturation).

Section 6. Mechanical ventilation

Mechanical ventilation is used to replace spontaneous breathing in the anesthetized, intubated or tracheotomized animals (pigs).
Initial respirator settings: tidal volume (8–10 ml/kg), respiratory rate (15–20/min)
Change the settings to induce hypo- and hyperventilation, or apply 4–5 cm of water for PEEP (positive end-expiratory pressure) in the expiratory line of the respirator to improve ventilation.
Take blood samples and measure blood gas values in the different settings.

Evaluation

Section 1.
- Correctly performed endotracheal intubation (40 points)
- Damage to the teeth with the laryngoscope (pressure on the teeth is indicated by an acoustic signal in the head model) (minus 10 points)
- Tracheal damage or injuries to surrounding areas during insertion of the tube (minus 5 points)
- Tube is inserted into oesophagus (a buzzer is sound in the head model) (minus 10 points)
- Endotracheal tube is inserted too deeply (under the tracheal bifurcation) (minus 5 points)
- Overinflation of the cuff (pressure damage) (minus 10 points).

Sections 2. and 3.
- Correctly performed measurements (10 points)
- Imperfect connection (leaking) between the capnograph line and the endotracheal tube leading to incorrect measurements (minus 5 points)
- Measurements are impossible due to incorrectly placed oximeter sensors (minus 5 points)

Section 4.
- Properly performed blood sampling (15 points)
- Improper use of stopcocks during sampling (minus 10 points)
- Sampling without discarding the first drops of blood (minus 5 points)
- Blood sampling into a nonheparinized syringe (minus 15 points)
- Air bubbles in the blood sample (minus 5 points)
- Omission of flushing the catheter with saline (minus 5 points)

Section 5.
- Properly performed analysis (15 points)
- Omission of mixing the blood sample immediately before analysis (minus 10 points)
- Performing blood gas analysis without discarding the first drops (minus 5 points)

Section 6.
- Proper use and changing the respirator settings (15 points)
- Improper connection between the respirator and the endotracheal tube or the tracheostomy tube (minus 15 points).
B6. MODULE

Catheterization skills

Learning objective/aims: The objective of this program is to let the students be familiar with the technique of the catheterization of the female and male urethra and the urinary bladder. The practice will be performed on phantoms. By the completion of this program the students should be able to introduce and remove a catheter correctly. They will be aware of the possible complications and how to avoid them.

Site: Skills laboratory

Required instruments: Foley catheter in appropriate size, urine container sack and tube, sponges for cleaning of the genital area, disinfectant, saline (in syringe) to fill the balloon, sterile lubricant (Instillagel), sterile forceps, gloves

Section 1.

Catheterization of the male phantom

Steps
- Wash the hands and put on the gloves.
- Lift the penis (about 60 degrees) with left hand and retract the foreskin (Fig. 1.).
- Take three sponges and soak them with disinfectant.
- Clean the urethral meatus three times (Fig. 2.).
- Take the syringe with the lubricant and inject some Instillagel into the urethra. The penis should be elevated during the whole process (Fig. 3.).
- The assistant opens the package of the catheter. Take the sterile forceps and grasp the catheter at some cm from the end.
- Insert the catheter gently into the urethra. The catheter must not be forced and more than 20 cm should be introduced (Fig. 4.).
- Take the syringe with saline and fill the balloon with 10 ml of fluid (Fig. 5.).
- Pull back the catheter gently until a slight resistance is met (Fig. 6.).
- Connect the catheter to the urine container sack.

Section 2.

Removal of the catheter from the male phantom

Steps
- Take a syringe and remove all fluid from the balloon.
- Elevate the penis and pull out the catheter gently.

Section 3.

Catheterization of the female phantom

Steps
- Wash the hands and put on the gloves.
- Spread the labia gently with left hand.
- Take three sponges and soak them with disinfectant.
- Clean the introitus three times from front to back (Fig. 7.).
- The assistant opens the package of the catheter. Take the sterile forceps and grasp the catheter at some cm from the end while the labia are being spread.
• Put Instillagel onto the first few cm of the catheter (Fig. 8.).
• Insert the catheter gently into the urethra. (Fig. 9.).
• Take the syringe and inflate the balloon with 10 mL of saline (Fig. 10.).
• Pull back the catheter gently until a slight resistance is met (Fig. 11.).
• Connect the catheter to the urine container sack (Fig. 12.).

Section 4.
Removal of the catheter from the female phantom

Steps
• Take a syringe and remove all fluid from the balloon.
• Spread the labia and pull out the catheter gently.

General mistakes
• Gloves are not taken on.
• Labia are not spread or penis is not elevated correctly.
• Wrong direction of disinfection
• Inappropriate application of lubricant
• Incorrect introduction of the catheter
• Balloon is not filled or filled in a wrong position.
• After the filling of the balloon the catheter is not pulled back to the right position.
• Fluid is not removed from the balloon before removing of the catheter.

Evaluation

Section 1.
9 points can be given if the entire process is performed correctly. Minus points if any of the steps misses or is performed wrong or the process is not in accordance with the rules of asepsis.

Section 2.
4 points can be given if the entire process is performed correctly. Minus points if any of the steps misses or is performed wrong. It is a serious mistake if the fluid is not removed from the balloon.

Section 3.
9 points can be given if the entire process is performed correctly. Minus points if any of the steps misses or is performed wrong or the process is not in accordance with the rules of asepsis.

Section 4.
4 points can be given if the entire process is performed correctly. Minus points if any of the steps misses or is performed wrong. Serious mistake if the fluid is not removed from the balloon.
“C” MODULES

In these modules, advanced interventions such as laparotomy, appendectomy, thoracocentesis and thoracotomy are introduced to interested students. These procedures are taught in simulated real-life, clinical surroundings and circumstances. The goals are to foster skills-based decision-making, and to broaden the correlation of physiology, anatomy and pharmacology to acute clinical care. Emphasis is placed on procedures, critical thinking and the assessment of skills, in order to develop the knowledge and skills to support a career choice in those specialties in which expertise in surgical anatomy is critical.
C1–2. MODULE
Advanced suturing skills

In the field of medicine today, simulation technology is increasingly available for learning invasive procedures. The Minor Skin Procedures program is about learning to perform minor surgical procedures on lesions which are on, in or just underneath the skin. The program assumes no prior knowledge of this topic. Exercises on simulated soft tissue models allow for repeatedly practice the skills needed for proficiency. The program provides detailed coverage and "hands-on" training of the following subjects: instruments and technique, ellipse excision of skin lesions, removal of epidermoid cysts, removal of lipomas, shave excision, curettage, snip excision of skin tags.

Site: Students’ operating room (OR).

Themes: Complex surgical procedures with advanced suturing techniques

Procedures
1. Ellipse incision and excision
2. Epidermoid cyst removal
3. Lipoma removal
4. Advanced suturing: end-to-end bowel anastomosis in 2 layers

Section 3.
Lipoma removal

The procedure is simulated in a pig skin phantom. Instruments: scalpel, forceps, scissors, needle, syringe, 1–2% lidocaine, sterile sponges, draping.

Steps (Fig. 3.)
- The lesion should be palpated before gloving and skin disinfection.
- Sterile glowing
- Skin disinfection and isolation of the affected area.
- Marking of the object (marking the line of the incision along the crease lines)
- Local anesthetic infiltration (in a circle or fan shape)
- Skin excision with a scalpel (usually shorter than the margin of the lesion; see Fig. 3.)
- Preparation and removal of the object (grabbed with forceps, prepared around in a blunt fashion)
- Skin closure (with Donati-type or intracutaneous stitches, since there is no tension)
- Disinfection with povidone-iodine solution
- Covering the wound with mull-sheets

Section 2.
Ellipse incision and excision

It is indicated to remove scars, benign fibroma, pigmented naevi. The procedure is simulated in a pig skin phantom. Instruments: scalpel, forceps, scissors, needle, syringe, 1–2% lidocaine, sterile sponges, draping.

Steps (Fig. 2.)
- Sterile glowing
- Skin disinfection and isolation of the affected area
- Marking of the object (Marking the line of the incision along the crease lines in an ellipse shape, the width of the ellipse will be determined: the lesion plus 2 mm on each side; recommended width-length proportion is 1:3.)
- Local anesthetic infiltration (in a circle or fan shape)
- Skin excision with a scalpel (performed outside the markings). The skin is stretched with one hand, hold the scalpel like a pen. Incise the corners first, cutting each one towards the centre of the incision.
- Removal of the lesion (The skin is grasped with forceps, checking that the excised ellipse consists of all layers of the skin down to the subcutaneous fat.)
- Wound closure (Subcutis: thin linen thread, interrupted stitches; skin: Donati stitches, subcuticular stitches are not recommended because of the excessive wound tension.)
- Disinfection with povidone-iodine solution
- Covering the wound with mull-sheets

Section 1.
Epidermoid cyst removal

The procedure is simulated in a pig skin phantom. Instruments needed: sterile scalpel, forceps, scissors, needle, syringe, 1–2% lidocaine, sterile sponges, draping.

Steps (see Fig. 1.)
- The lesion should be palpated before gloving and skin disinfection.
- Sterile glowing
- Skin disinfection and isolation of the affected area.
- Marking of the object (marking the line of the incision along the crease lines in an ellipse shape)
- Local anesthetic infiltration (in a circle or fan shape)
- Skin incision with a scalpel along the marked line
- Preparation and removal of the object (grabbed with forceps, prepared around in a blunt fashion)
- Skin closure (with Donati-type or ic. stitches, since there is no tension)
- Disinfection with povidone-iodine solution
- Covering the wound with mull-sheets

Fig. 1. Epidermoid cyst removal
Section 4.

Advanced wound closure. Suture of the bowel in two layers, end-to-end anastomosis

This procedure is practiced on a phantom (porcine bowel).

Steps

- Isolation: before opening the intestinal lumen, the site of enterotomy should be draped with sterile towels.
- Emptying: if any content is palpable in the lumen, it should be gently pushed to aboral direction.
- Temporary closure of the lumen: the affected part of bowel should be reversibly closed with 2 atraumatic Klammer forceps both in oral and aboral directions.
- Enterotomy (parallel with the bowel axis; at the antimesenterial side. The serosa is usually cut with a scalpel, the deeper layers with electrocautery).
- The bowel lumen should be cleaned with povidone-iodine sponges.
- A transverse approximation of the edges of the bowel wound is performed perpendicular to the longitudinal enterotomy.
- Stay stitch: insert the first two stitches seromuscularly into the two opposite ends of the wound.
- First layer: interrupted stitches in 3–5 mm distance seromuscularly.
- Second layer: to cover the first suture line with serosa; the distance between the individual stitches is 3–5 mm.

Evaluation

Section 1.

- The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (25 points).
- Typical mistakes (minus 5 points/mistake): sterility is broken; anesthetic infiltration is forgotten; the direction and length of the incision is not proper; problems with instrument handling during wound closure.

Section 2.

- The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (25 points).
- Typical mistakes (minus 5 points/mistake): sterility is broken; anesthetic infiltration is forgotten; the direction and length of incision is not proper (typically the width of the excised ellipse is too big, and its depth is too small); problems with instrument handling during wound closure; wound closure and knotting problems due to tension of the wound.

Section 3.

- The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (25 points).
- Typical mistakes (minus 5 points/mistake): sterility is broken; anesthetic infiltration is forgotten; the direction and length of incision is not proper; problems with instrument handling during wound closure.

Section 4.

- The student is able to perform the whole procedure in the right order and with maximal compliance with the rules of sterility (25 points).
- Typical mistakes (minus 5 points/mistake): steps (e.g. emptying the lumen, temporary closure of the bowel, disinfection of the lumen) are missing; enterotomy is not performed by electrocautery, but with scalpel; approximation of the bowel wound edges is performed not perpendicular to the enterotomy; problems with the patency of the anastomosis.
C3–4. MODULE

Complex operations in practice

Site: Students’ operating room, skills laboratory

Themes: Abdominal drainage: diagnostic and therapeutic peritoneal lavage; laparotomy; tracheostomy; thoracic drainage: chest tubing

Procedures:
1. Diagnostic peritoneal lavage (DPL)
2. Therapeutic peritoneal lavage (TPL) (dialysis)
3. Middle median laparotomy, inspection of abdominal organs
4. Tracheostomy, insertion of a tracheostomy tube
5. Insertion of a chest tube

Section 1.

DPL

Aim: Diagnosis of intraperitoneal injury (bleeding) following blunt or penetrating abdominal trauma in order to decide whether or not a surgical exploration of the abdomen is necessary. Students are working in operating teams consisting of a surgeon, a first assistant and a scrub nurse (the roles can be changed during the intervention).

Steps
- The anesthetized pig is laid on the operating table in supine position, the urinary bladder is catheterized (in human patients local anesthesia is used.)
- The members of the operating team should put on shoe covers, cap and mask before entering the operating room. Scrub preparation of hands, gowning and gloving should be performed.
- Scrub preparation and draping of the operative field is carried out.
- Skin incision: 1–2 cm below the umbilicus, the surgeon makes a 1–2 cm long median incision with scalpel. The skin knife should be thrown in the kick bucket.
- Subcutaneous fat is dissected with the deep knife and the linea alba is explored.
- Bleeding must be handled carefully (capillary oozing: tamponade, small vessels: diathermy, larger vessels: ligation).
- Close to the linea alba, the surgeon and the first assistant grasp and lift the rectus sheet with tissue forceps on his or her own side. Between the two forceps, a small, 3–4 mm cut is made on the linea alba, the edges are gripped and elevated with two Backhaus clamps.
- The peritoneum is stabbed with the trocar of the lavage catheter. The trocar is then removed, and the catheter is introduced to the sacrum. If you do not have a lavage catheter with trocar, before introducing the catheter, the peritoneum should also be incised. The Seldinger technique can also be used for the introduction of the catheter.
- A 10 mℓ syringe is placed on the catheter and peritoneal fluid is sucked. If the aspirate does not seem to be contaminated with blood, bile, etc., peritoneal lavage is performed.
- Peritoneal lavage: 10–15 mℓ/kg 37 °C Ringer-lactate is infused into the peritoneal cavity for 20 min. After equilibration for 3–10 min (it can be facilitated by a gentle massage of the abdomen), the infusion sack is placed on the floor and the washing fluid is collected by gravity. At least 30% of the infused solution should be recovered. The fluid should be tested by laboratory investigation for the presence of red (RBC) and white blood cells (WBC), bacteria, amylase, bile, etc.
- If positive (RBC: >10⁶/mm³, WBC: ≥5 × 10⁹/mm³), an exploratory laparotomy should be made. If negative, the catheter is removed, and the skin wound is closed with Donati stitches.

Section 2.

Practicing of TPL on phantom

Aims: Removal of accumulated metabolic end products and toxic substances in uremia (in acute or chronic renal failure), acute hepatic failure and intoxications, etc. A dialysis catheter is introduced or, in cases of chronic peritoneal dialysis, it is implanted in the patient. The inner end of the catheter is in the Douglas space, it exits the abdominal wall lateral to the midline at one third of the distance between the umbilicus and the symphysis, and its outer end is closed by a screw cap.

Site: Skills laboratory

Steps
- Hang on the bag with 37°C dialysing solution on the infusion stand. The protective cover is removed from the port of the bag, and the spike of the administration set is inserted.
- Unscrew the sterile cap of the dialysis catheter.
- Screw a closed 3-way stopcock on the catheter.
- Attach the tubing of the administration set to one of the connectors of the stopcock.
- Open the stopcock and the plastic roller clamp on the tubing and the dialysing solution is introduced in the abdomen.
- When the bag is emptied, close the roller clamp and the stopcock (in humans, the empty bag is changed for a full one, and the abdomen is filled with 2 liters of dialysing fluid.)
- After the appropriate equilibration time (min. 20 min), place the empty bag connected to the catheter on the floor. The fluid is drained by gravity to the bag.
- After finishing the dialysis, close the catheter with the screw cap.

Section 3.

Middle median laparotomy

Aim: Diagnosis of abdominal diseases (trauma, bleeding, peritonitis, gastrointestinal diseases, tumors, metastases, etc.) (exploratory laparotomy), if the diagnosis cannot be secured by noninvasive methods; surgical interventions on abdominal
organ. Students are working in operating teams consisting of a surgeon, a first and a second assistant, and a scrub nurse (the roles can be changed during the operation).

Site: Students’ operating room (OR)

Steps
- The anesthetized female pig is laid on the operating table in supine position, its urinary bladder is catheterized, and the trachea is intubated (in male pigs, the penis is attached to the abdominal wall from 1–2 cm below the umbilicus, and it makes more difficult to perform the midline incision).
- The members of the operating team should put on shoe covers, cap and mask before entering the operating room. Scrub preparation of hands, gowning and gloving should be performed.
- The scrub nurse gives a sterile laparotomy sponge to the surgeon and another one to the first assistant.
- The wound towels are placed on the two sides of the planned incision.
- Placing their left hand on the wound towels, the surgeon and the first assistant stretch the skin.
- The scrub nurse gives a skin knife (#15 blade, #4 handle) to the surgeon and a sponge-holding clamp with a sponge to the first assistant.
- The surgeon performs a 15–20 cm skin incision in the midline exactly over the linea alba running through the umbilicus. (In humans, the umbilicus must not be cut, the incision should go round the umbilicus from the left.)
- Bleedings are handled carefully.
- The scrub nurse grasps a 1/4 curved skin needle with a Mayo-Hegar needle holder and inserts a 2–0 nylon thread in the eye of the needle. She gives the needle holder to the surgeon and tissue forceps to the surgeon and the first assistant.
- The surgeon fixes both laparotomy sponges to the appropriate wound edges with three simple interrupted stitches. The threads are knotted by the assistant.
- The surgeon cuts subcutaneous tissues with a diathermy pencil until the linea alba is reached. Bleedings are stopped.
- The surgeon and the first assistant pick up the rectus sheets with two tissue forceps and the surgeon makes a small incision on the linea alba between them.
- The surgeon elevates the linea alba with dressing forceps placed in the peritoneal cavity, and he/she lengthens the incision with Mayo scissors or a diathermy knife both cranially and caudally to the wound corners. If it is made exactly along the linea alba, the rectus sheets will not be severed.
- Above the umbilicus, the thick, fatty falciform ligament is clamped with two Péan hemostats and cut between them.
- The edges of the peritoneum and the linea alba are clamped with three Mikulicz clamps on both sides. Two laparotomy sponges can also be fastened to the wound edges on both sides to isolate the peritoneal cavity from the subcutaneous wound.
- The abdominal wall is lifted up with the Mikulicz clamps by the assistants, and a Gosset self-retaining retractor is placed into the abdominal wound. Care should be taken not to grasp the greater omentum and the intestines between the jaws of the retractor and the abdominal wall.
- After median laparotomy, the following organs can be examined: the greater omentum; the stomach; the spleen; the liver, gall bladder, bile ducts; the small and large intestines; the pancreas; the kidneys and adrenal glands; the urinary bladder. The abdominal organs can be moved with and placed only on saline-moistened laparotomy sponges.
- After the inspection of the abdominal organs, the abdominal wall is closed in three layers. The Gosset self-retaining retractor is released and removed.
- Suturing is usually done from the cranial to the caudal wound corner. The wound of the peritoneum and the linea alba is closed with a half-circle muscle needle and #40 linen thread, with a continuous running suture. The peritoneum and the linea alba is grasped with tissue forceps at the cranial wound corner and the first stitch is placed by the surgeon on both sides. The first assistant ties a knot on the free end of the thread, and cuts the short end of it. He/she keeps the thread under continuous tension with his/her right hand and guides the thread with his/her left hand during sutureting. In most cases, the wound edges can be held well with the Mikulicz clamps. They are removed step-by-step. When the last stitch has been placed at the caudal wound corner, only one-third of the thread is pulled through the wound, and it is knotted by the assistant with the double thread which has been left on his/her side. The thread is then cut short.
- The subcutaneous wound is closed with #80 linen thread, with simple interrupted sutures. (In humans, absorbable threads are used).
- The skin is closed with Donati stitches, using a skin needle and 2–0 nylon thread. The wound is disinfected with povidone-iodine and covered with a bandage.

Section 4.

Upper tracheostomy

Aim: The maintenance of airways, if the passage cannot be established by any other means (e.g. upper airway obstruction threatening with asphyxia), or if the endotracheal intubation (after 1 week), or cricothyrotomy (after 48 hours) must be terminated. Students are working in operating teams consisting of a surgeon, a first assistant and a scrub nurse (the roles can be changed during the operation).

Steps
- The anesthetized pig is laid on the operating table in supine position, the trachea should be intubated.
- The members of the operating team should wear shoe covers, cap and mask before entering the operating room. Scrub preparation of hands, gowning and gloving should be performed.
The skin of the neck is scrubbed, the operative field is isolated with four towels or with a drape with a small round hole.

The thyroid and cricoid cartilages are palpated and the first and second trachea cartilages are localized. Between them, a transverse skin incision is made with a scalpel. The bleeding from the subcutaneous veins is stopped. It can be usually treated by compression.

The wound edges are then grasped and elevated with two tissue forceps, and the subcutaneous tissues are cut transversally with Mayo scissors. Bleeding is carefully stopped.

At the bottom of the wound, the white fascia line, the linea mediana alba colli comes into sight. The fascia is lifted up with two dressing forceps, and the white line is cut longitudinally with scissors.

The strap muscles are grasped with dressing forceps on both sides and separated with scissors by blunt dissection in the midline. At the bottom of the wound the trachea becomes visible.

The assistant retracts the muscles with two muscle retractors. The fascia covering the trachea is then lifted up with dressing forceps and divided longitudinally with scissors. The first and second tracheal cartilages are now being exposed.

Injury to the cricoid and first tracheal cartilages is avoided. The membrane between the first and second tracheal cartilages is incised transversally with a scalpel. Bleeding is handled accurately.

A mosquito hemostat is placed into the opening. The second tracheal ring is elevated by it, and cut with scissors in the midline downwards. The third and fourth tracheal cartilage can also be divided if necessary. This way, a T-shaped opening is formed. The bleeding is stopped.

An atraumatic stitch is placed into both edges of the cut cartilage. The edges can be opened by the stitches like the case- ments. In the opening, the endotracheal tube becomes visible.

An appropriate size tracheostomy tube is selected. The cuff of the tube should be tested for leakage.

The air is sucked from the cuff of the endotracheal tube with a syringe, the tube is then withdrawn over the stoma.

The opening is retracted with the aid of the stitches. The tracheostomy tube is inserted into the stoma and intro- duced into the trachea. The obturator is removed from the tube. The cuff is inflated.

The stitches are removed from the cartilage, or they are individually knotted, then tied together over and under the tube.

The skin wound is sewed with Donati sutures on both sides of the tube.

A cotton tape is put into the opening of both edges of the tube, and they are tied together behind the patient’s neck, thus the tube is secured.

In infants and small children, because of the different anatomical situation, a lower tracheostomy is performed. Usually a midline incision is made from the lower edge of cricoid cartilage to the jugulum, and the trachea is opened on the lower part.

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**Steps**

- The anesthetized pig is laid on the operating table in supine position, the trachea should be intubated.
- The members of the operating team should wear shoe covers, cap and mask before entering the operating room. Scrub preparation of hands, gowning and gloving should be performed.
- The standard sites of the insertion of the chest tube are: 1. the midaxillary line, between the 5th–7th ribs; 2. the medioclavicular line, between the 2nd–3rd ribs.
- The skin is scrubbed at site of the insertion. Draping is optional.
- A 2–3 cm long transverse skin incision is made exactly over the upper margin of the rib. The thoracic wall should be penetrated at this site (at the lower margin, nerves and vessels can be damaged).
- The parietal pleura is stabbed with a curved Péan hemostat or a trocar. An index finger is then introduced to explore the pleural cavity and free adhesions.
- A drain tube, the inner part of which is perforated, and the outer end is closed with a Péan hemostat, is introduced with the curved Péan hemostat or through the trocar into the pleural cavity (in case of pneumothorax, along the inner surface of the parietal pleura to backward and upward direction into the apex of the chest).
- To fix the drain, a single skin suture is made beside the drain, the thread is knotted, then wrapped round the tube, and a knot is tied.
- A U-form skin stitch is done around the entry of the drain, and the double thread is winded up on a sponge.
- The tube is attached to a suction system (wet, dry, Bülau drainage, central suction system, etc.).
- Removal of the drain: The thread that fixes the tube is cut, and the tube is pulled out. The skin wound is closed by pulling and knotting the U-stitch.

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**Evaluation**

**Section 1.**

The students (in surgeon’s, assistant’s and scrub nurse’s role) should perform scrub preparation of their hands, gowning and gloving, scrub preparation and draping of the operative field, surgical exposure of the linea alba below the umbilicus, introduction of the lavage catheter, DPL, removal of the catheter and wound closure. (25 points in each role). Students should be able to work in each role. Typical errors (minus 1 point each):

- Errors in the aseptic technique. Unrecognized, uncorrected mistakes in the following:
  - putting on caps, masks, shoe covers;
  - mechanical scrub preparation and disinfection of hands;
  - gowing and gloving;
  - behavior and movement in the operating room;
  - scrub preparation and draping of the surgical area;
  - maintaining asepsis during operation.
Errors in the surgical technique:
- incorrect position at the operating table;
- use of inadequate instruments (e.g. dressing forceps for grasping skin and linea alba instead of tissue forceps or Backhaus clamps, general purpose scissors instead of Mayo scissors for blunt dissection, etc.) or materials (e.g. muscle needle and thin thread for suturing skin wound);
- incorrect handling and passing of instruments;
- errors in tying knots (e.g. no square knots are tied, knots are too loose or too tight, etc.);
- errors in skin incision (e.g. skin is not stabilized; cutting is too long, too short, too superficial or too deep, several parallel superficial incisions are made, etc.);
- errors in dividing sc. tissue (e.g. cutting is done with scissors instead of diathermy, the incision does not reach the linea alba, etc.);
- bleeding is not handled adequately;
- errors in the introduction of lavage catheter (e.g. the trocar is not removed from the catheter after it has entered the peritoneal cavity, the end of the catheter is not introduced toward the sacrum, it is not checked before the lavage whether blood can be sucked from the peritoneal cavity);
- errors in the lavage (e.g. the volume and temperature of the washing fluid or the equilibration time is not appropriate, during the collection of the washing fluid, the infusion bag is not lowered below the level of the operating table);
- the catheter is removed before 30% of the infused volume has been recovered;
- errors in wound closure (e.g. the skin stitches are not placed properly, the wound edges are everted or inverted, the knots are tightened very much, the wound is not disinfected, etc.).

Errors in the aseptic technique (see Section 1). Errors in the surgical technique (see Section 1), including:
- errors in connection with the opening of the peritoneal cavity (during cutting, the linea alba is not elevated, the rectus sheets are severed, the incision exceed the corners of the sc. wound; the peritoneum edges are not clamped with Mikulicz clamps, the jaws of the Gosset self-retaining compresses abdominal organs to the abdominal wall, etc.);
- the abdominal organs are not handled gently (no saline moistened laparotomy sponges are used to protect them from drying out);
- errors in wound closure (e.g. the suture is not secure, the suture is loose because the assistant does not keep the thread under continuous tension during suturing; the sc. stitches does not involve the deeper layer of the sc. wound and a dead space is formed, the sc. stitches are too close to the edges of the skin wound, the skin stitches are not placed properly, the wound edges are everted or inverted, the knots are too tight, the wound is not disinfected, etc.).

Section 2.

The student should perform TPL under aseptic conditions as described above (5 points). Typical errors (minus 1 point each):
- Sterility is broken during the procedure.
- The set is improperly assembled (the temperature of the dialyzing solution is not controlled; the three-way stopcock is not handled properly; the flow rate regulator is not opened, etc.);
- During the removal of the dialyzing fluid, the collecting sack is not placed on the floor.

Section 3.

The students (in surgeon’s, first and second assistant’s and scrub nurse’s role) should perform scrub preparation of their hands, gowning and gloving, scrub preparation and draping of the operative field, middle median laparotomy, inspection of abdominal organs and closure of the abdominal wound in three layers in an anesthetized pig under aseptic conditions (40 points in each role). Students should be able to work in each role. Typical errors (minus 1 point each):

Errors in the surgical technique (see Section 1). Errors in the aseptic technique (see Section 1), including:
- errors in connection with tracheostomy and insertion of the tracheostomy tube (e.g. the incision is made between the cricoid and first tracheal cartilages; the cuff of the tracheostomy tube is not tested for leakage before introduction; the air is not sucked off from the cuff of the endotracheal tube before withdrawal; the retracting stitches are placed very close to the edges of the cut cartilage and they are torn out; the obturator is not removed from the tube after insertion, the cuff is not inflated, etc.);
- errors in wound closure (e.g. the skin stitches are not placed properly, the wound edges are everted or inverted, the wound is not disinfected, etc.).

Section 4.

The students (in surgeon’s, first assistant’s and scrub nurse’s role) should perform scrub preparation of their hands, gowning and gloving, scrub preparation and draping of the operative field, tracheostomy, insertion of a tracheostomy tube and closure of the skin wound in an anesthetized pig under aseptic conditions (40 points in each role). Students should be able to work in each role. Typical errors (minus 1 point each):

Errors in the surgical technique (see Section 1).
- Errors in the surgical technique (see Section 1), including:
- errors in connection with tracheostomy and insertion of the tracheostomy tube (e.g. the incision is made between the cricoid and first tracheal cartilages; the cuff of the tracheostomy tube is not tested for leakage before introduction; the air is not sucked off from the cuff of the endotracheal tube before withdrawal; the retracting stitches are placed very close to the edges of the cut cartilage and they are torn out; the obturator is not removed from the tube after insertion, the cuff is not inflated, etc.);
- errors in wound closure (e.g. the skin stitches are not placed properly, the wound edges are everted or inverted, the wound is not disinfected, etc.).

Section 5.

The students (in surgeon’s, first assistant’s and scrub nurse’s role) should perform scrub preparation of their hands, gowning and gloving, scrub preparation of the site of the intervention, insertion and fixing of a chest tube, removal of the tube and closure of the skin wound with a U-stitch in an anesthetized pig under aseptic conditions (25 points in each role). Students should be able to work in each role. Typical errors (minus 1 point each):
- Errors in the aseptic technique (see Section 1).
- Errors in the surgical technique (see Section 1), including:
- errors in connection with skin incision (e.g. skin is not stabilized; cutting is made at the lower margin of the rib, or not at the standard sites of chest tubing; its length or depth is not appropriate, parallel superficial incisions are made, etc.);
- the parietal pleura is stabbed at the lower, and not at the upper costal margin;
- the outer end of the chest tube is not closed with a Péan hemostat;
- the tube is introduced to an inadequate direction or site;
- it is not fixed, or the way of fixing is inappropriate (no U-stitch is placed around the entry of the tube, or it is not wound up on a sponge; the U-stitch is pulled out);
- the wound is not disinfected, etc.
C5. MODULE

Minimally invasive surgery.
Basic laparoscopic coordination exercises

Themes: Introduction to laparoscopic visual perception, eye-hand coordination, practicing of needle loading and driving, suturing and intracorporeal knotting in a box trainer. 3D virtual reality (VR) training.

Site: Students’ operating room (OR)

Procedures:
1. Training in a VR computer-assisted laparoscopic simulator
2. Equipments
3. Lacing a thread in a practice box
4. Suturing a latex glove, laparoscopic knotting technique—intracorporeal knotting

Section 1.
Training in a VR computer-assisted laparoscopic simulator

System requirements: LapSym (Surgical Sciences, Sweden)
3D simulation computer program

Tasks: Individual task list is created for the participants of the course (with own user name—see below).

Course: Surgical list
Description:
Ownership: Public, owned by (blank)
Settings:
Blocks can be completed in any order
Blocks can be completed in any order
Editing is not allowed when course completed

Scheduled tasks (9):
Navigation (Instrument Navigation)
Camera navigation (Camera Navigation)
Instrument Navigation (Instrument Navigation)
Suturing (Suturing)
Clipping (Clipping)
Clipping (Clipping)
Cutting (Cutting)
Cutting (Cutting)
Suturing (Suturing)

Currently assigned students (129)

Task 1. Camera navigation
- The right hand holds the camera and an object should be brought into its focus by moving the camera closer to the object. At an ideal distance green blinking occurs.
- The camera should be stabilized in this position for 3 sec.

Task 2. Instrument navigation
- Left and right instruments should reach objects in the field marked by the same color.

Task 3. Grasping
- Objects should not only be touched, but grasped with the right or left instrument, torn from the base and put into a red target area.

Task 4. Cutting
- The green area is grasped with the instrument held in the right hand and stretched.
- A blue area appears which should be cauterized (grasped with the left hand, the virtual electrocautery is operated with a foot pedal).

Task 5. Clipping and cutting
- 5.1. The vessel is grabbed with the right hand and a clip applicator is chosen as an instrument held in the left hand. After sufficient tension, blue areas appear.
5.2. A clip is applied with the left hand, and this instrument is replaced by a grasper. Grasper in the left hand is stretching the vessel. The right instrument is switched to a clip applicator and a second clip is applied with the right hand.

5.3. After applying sufficient tension again with the left instrument, a blue area appears. The right instrument is replaced by scissors by which the vessel at the blue target area is cut.

Section 2.
Equipment, adjustments

System requirements: Laparoscopic tower with monitor, camera and control box, light cable and light source 0 degree 10 mm laparoscope, cables and connectors for the system. Operating table, trainer box, laparoscopic graspers, threads.
- Everything is turned on, the camera is white balanced, focused, and the ideal magnification, zoom is adjusted.
- The table is tilted to accommodate the student's height.
- The trainer box is set up to accept the laparoscope in the shorter triangle.

Section 3.
Lacing a thread in a practice box

System requirements: Laparoscopic tower, trainer box, laparoscopic graspers, threads.

Setup: The laparoscopic camera is placed in a trainer box and attached to a laparoscopic tower. An atraumatic needle is loaded into the needle driver. It is then inserted through a path of hooks of a practice board. All movements are visually guided, checked on the monitor. Directions: 3 o'clock to 9 o'clock.
- Needle loading: To introduce the needle, the thread should be grasped with the assisting instrument 3–4 cm from the needle. By holding the thread at this point, the needle can be dangled above the tissue surface and slowly lowered so that the tip of the needle touches the tissue.
- If it is necessary to adjust the direction in which the needle is pointing, the assisting grasper can be rotated in a clockwise or anticlockwise manner to guide the needle point in the proper direction for correct loading, exposing the curvature for grasping.

Section 4.
Suturing a latex glove

Suturing exercises begin with suturing a latex glove that has two rows of dots marked in 3 o'clock and 9 o'clock direction and a perpendicular cut made through it creating the proposed wound edges to be approximated. This facilitates the acquisition of skills of needle handling, precision entrance-exit bites, suturing, and the knot tying sequence.
The needle driver can carefully grasp the needle at 2/3 of length; the tip of the curved needle driver should point towards the back end of the needle (“spoon up” position). The needle should be driven in a course that is perpendicular to the suture line, by following its curvature to reduce leverage and tissue trauma at these entrance and exit points.

Interrupted suture line: 10 pairs of dots are connected with individual knots. During the entrance and exit bites the needle should go through the marked dots. Time limit is 3 min for each stitch, and 30 sec for the square knot.

Continuous suturing: It begins with a single knot and without cutting the long thread, and additional stitches are made progressing toward the operator. The stitches are spaced 3–5 mm apart depending on the structure and the nature of reconstruction. Preferably monofilament suture is used which slides easily in the multiple needle tracks made in the tissue. Greater attention should be paid to the setup and to the long tail as it is “followed” by the assisting instrument since loose or purse-stringed suture-line can be a problem. Although it is more rapid than single stitching, for good results considerable skill and experience is needed. The terminating knot can be either a “three legged” or “Aberdeen” or “Crochet” knot.

Section 5.
Laparoscopic intracorporeal knotting technique. Square/slip, convertible locking or slip knot

Steps
The first flat knot (hitch)

After the needle has made its exit and the thread is pulled, leaving a short tail about 3 to 5 cm long, the needle is placed in the 6 o’clock direction out of the field in a secure location. The long tail is on the left side and the short tail is on the right side.

Starting position: the needle holder (NH, right hand) grasps the long tail and brought over to the right side of the field, opposite the short tail and below it (“C” configuration). (N.b.: there should be a 3:1 ratio or greater between the length of the long tail and the short tail).

First wrap: while holding the long tail with the NH (right hand), the assisting forceps/grasper (AG) (left hand) is placed over the suture and the long tail is wrapped once over then under the AG.

Pulling the short tail: the AG (left hand) reaches over to the right side to grasp the short tail and then the two instruments pull in opposite directions, the AG to the left and the NH to the right, tying parallel with the entrance-exit points of the stitch. This is the first flat hitch to the right.

Switching the suture: the NH brings back the long tail to the midline in a way that the long tail curves below the proposed knot. The suture is then handed over to the left hand.
The AG (left hand) holds the long tail opposite the short tail (and below it), creating a “reversed C” configuration (mirror image of the staring position). The NH (right hand) is placed over the reversed C and the thread is wrapped once over then under the instrument.

The second (opposing) flat knot.

The NH (right hand) reaches to the left side and grasps the short tail (again, move both instruments together toward the short tail).

The instruments move in opposite directions pulling the short tail through the loop, NH to the right and the AF to the left, parallel with the stitch.

The result is a square knot.

Conversion of the square knot: The sutures are grasped on the same side above and below the knot. They are pulled apart. The pulled suture leg becomes straight, providing a “guide wire” on which the pretzel-shaped double loop can easily slide.

The slipping configuration permits pushing the knot tighter.

After the knot is satisfactorily tight, the slipping form needs to be reconverted to a locking form. It is accomplished by first pulling the short tail and the same time pulling the long tail to the original tying direction. This should flip the knot back to the original square formation. To ensure a secure stitch, an additional flat knot is placed on top.

Evaluation

Section 1.

It is based on parameters that permit quantitative evaluation of different components of coordination skills. The student passes the exam if meets the statistical requirements (duration, coordination, avoid tissue damage) calculated by the software of the simulator program (see below).

<table>
<thead>
<tr>
<th>Instrument Navigation Results</th>
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<tbody>
<tr>
<td>Requirements: Default</td>
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<td>Overall Score: 100%</td>
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<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Graph</th>
<th>Min Max Passed Score</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
<tr>
<td>Left Instrument Move (%)</td>
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<tr>
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<td>Right Instrument Path Length (m)</td>
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<tr>
<td>Right Instrument Angular Path (degree)</td>
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<tr>
<td>Max Damage (0)</td>
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<td></td>
<td>0 30: Passed 100%</td>
</tr>
</tbody>
</table>
Practical Skills Syllabus

Examples of typical errors (see below):

Section 2.
- The student was able to accomplish the whole task (loading and lacing the needle through the practice board) in 10 min (5 points)

Section 3.
- Success at needle handling, precision of entrance-exit bites on the rubber pad when suturing (3 stitches in 5 min; 5 points).

Section 4.
- Level 1: the student is able to perform the whole knotting procedure (2 points);
- Level 2: the student is able to perform the sliding knot and tighten it (3 points);
- Level 3: a complete knot within 2 min (4 points);
- Level 4: a complete knot within 30 sec (5 points);
- Level 5: left-handed complete knot within 30 sec (5 points).

C5. MODULE – BASIC LAPAROSCOPIC COORDINATION EXERCISES
C6. MODULE – ADVANCED LAPAROSCOPIC SKILLS TRAINING

Advanced laparoscopic skills training

Themes: Economy of movements, choreographed maneuvers, flawless technique, touch confirmation and intracorporeal suturing are in the focus of these in vitro and in vivo exercises.

Site: Students’ operating room (OR)

Procedures:
1. Linear two-layer suturing of ex vivo organs (stomach, bowel)
2. In vivo laparoscopic operative setup
3. Cystostomy (two-layer suturing of organs in vivo)
4. Enteral procedures in vivo
5. Gastric procedures in vivo
6. Gynecology procedures in vivo
7. Urology procedures in vivo

Schedule (in case of postgraduate training):

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>L1</td>
<td>Principles of magnified surgery (lecture)</td>
</tr>
<tr>
<td>1st</td>
<td>P1</td>
<td>Training with 3D computer-assisted laparoscopic simulator (first try)</td>
</tr>
<tr>
<td>1st</td>
<td>P2</td>
<td>Equipment, adjustments. Suturing a latex glove, laparoscopic knotting technique/intracorporeal knotting</td>
</tr>
<tr>
<td>1st</td>
<td>P3</td>
<td>1. Linear two-layer suturing of organs ex vivo (stomach, bowel)</td>
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<tr>
<td>2nd</td>
<td>P4</td>
<td>2–3. Cystostomy (two-layer suturing of organs in vivo)</td>
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<tr>
<td>2nd</td>
<td>P5</td>
<td>4. Enteral procedures in vivo</td>
</tr>
<tr>
<td>3rd</td>
<td>P6</td>
<td>Specialty exercises (5/6/7)</td>
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<tr>
<td>3rd</td>
<td>P7</td>
<td>Specialty exercises (5/6/7)</td>
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<tr>
<td>3rd</td>
<td>P8</td>
<td>Training in a computer-assisted laparoscopic simulator (second try)</td>
</tr>
<tr>
<td>3rd</td>
<td>E</td>
<td>Evaluation, test</td>
</tr>
</tbody>
</table>

Section 1.
Linear two-layer suturing of ex vivo organs (stomach, bowel)

Steps
- Setup: Stomach with greater curvature toward the student.
- Use electrocautery hook tip with elbow down to mark proposed line of incision every 5 mm.
- Open up marked line with hook cautery tip, first seromuscular than mucosal layer.
- Place first stitch into the further apex and use it to suspend the corner and create a slanted suture-line.
- Place individual stitches about 5 mm apart, first in mucosal incision using 2–0, 3–0 Vicryl suture.
- Place 2–0, 3–0 silk sutures in seromuscular incision, in the same manner.

Section 2.
In vivo laparoscopic operative setup

Steps
- The animal (minipig) is positioned in general anesthesia according to the planned procedure and the surgeons comfort. For gastric procedures the head is pointing toward the monitor, for urinary bladder procedures bottom toward the monitor. Ideally a coaxial relationship exists among the monitor, proposed suture-line, the laparoscope, and the surgeon.
- The ports are placed in a strategic, measured manner to further improve surgeon’s comfort. The proposed operating site is marked on the abdominal surface. The view and suturing port positions are then marked, using the actual instruments. A triangle is created: laparoscope at the apex, NH forward to the right, AG forward to the left.
- First the view port is placed, then under direct visual control the rest of the ports.
- After testing the view and suturing port positions, if any found in not a satisfactory location, it is removed, the skin incision closed and a new, better location is selected.

Section 3.
Cystostomy (suturing of organs in vivo)

Steps
- The organ is half full or empty. The incision is extended from the bladder neck to the proximal apex of the bladder. It is important to dot the proposed incision first. It is then opened from proximal to distal direction, cutting through all layers at once. The incision should follow the dotted line and should be straight without jagged edges.
- The first stitch should go to the distal end of the cut and used as a suspension stitch. The long tail is brought out through the abdominal wall and secured in an ideal tension, providing good visibility and excess to suture.
- The needle should penetrate all layers including the mucosa, taking a bite that is strong enough to hold the approximated edges together and provide a hydrostatic seal. Distances of individual stitches should be also adequate.
- After completing the interrupted suture a second row can be sutured, this time with running sutures and imbrication of the edges.
- Meantime the bladder is filling up, and by the end of suturing it is obviously enlarging if the suture is hydrostatic.

Section 4.
Enteral procedures in vivo.
Entero-enterostomy

Steps
- After creating an ideal access, either a small bowel or colon segment is isolated, clamped, stabilized and transected. The suturing technique should follow the traditional anastomosis technique.
Interrupted suturing begins with the placement of primary stitches aligning the ends without twisting and excessive tension. The secondary stitches are placed to bring together and seal the edges. Hydrostatic seal is important to prevent leakage.

Continuous suturing is more rapid, although requires considerable skill and experience. It begins with the primary stitches where the long tail is not cut but left intact and follows the needle in the channel cut by the needle. The finishing knot is either tightened to itself (Crochet knot) or the short tail of the other primary stitch.

Section 5.
Gastric procedures in vivo.
Gastro-jejunostomy

- The animal is placed with head toward the monitor.
- Instrument and view ports are placed to access the lower gastric region.
- A loop of small bowel is pulled up to the location of anastomosis and secured with a generous stitch going through only one wall to the full layer gastric wall at the apex of the anastomosis.
- This suture is pulled through the abdominal wall and secured in a position that creates an ideal exposure of the anastomosis line.
- A 5 cm length is measured from the point of suspension and the second stitch is placed. The line of opening is marked on both the enteric and gastric side.
- An incision is made on both sides and a center, posterior stitch is placed. Using single layer technique, the posterior row is accomplished making a watertight seal and including the gastric mucosa.
- The anterior row is united in a continuous suture, tying to the tail of the second stitch.
- Testing is accomplished and the anatomic line is thoroughly inspected. Where gaps are found, they are repaired.

Section 6.
Gynecology procedures in vivo.
Tubo-tubal anastomosis

Steps
- A female animal is positioned on the operating table, butt forward to the monitor. Instrument ports are placed to access the symphysis.
- The bicornual uterus provides ample length to work with and somewhat larger and sturdier than the human organ. In transecting bleeding is considerable, and it is a challenging exercise.
- Using 5.0 to 7.0 sutures four full-layer stitches are placed in a quadrangular formation.
- Secondary stitches can be placed in-between the primary ones.

Section 7.
Urology procedure in vivo.
Urethro-vesicular anastomosis

Steps
- Same animal setup is used as for the gynecology procedure, butt toward the monitor.
- The urinary bladder is drained and retracted to expose the bladder neck (BN). Retracting stitch is placed to prevent slipping back.
- BN is transected, bleeding is controlled.
- Suturing starts at 7 o’clock and either interrupted or run toward 6, 5, 4 o’clock direction until tight closure is accomplished. Mucosa is included in both entrance and exit bites. Access BN gap is sutured in a tennis racket handle style.
- The closure is inspected for hydrostatic seal and possible gaps and if needed additional superficial stitches are placed.

Evaluation

Section 1.

- Good coaxial lineup (2 points)
- Correct port positions for suturing (2 points)
- Improving setup by replacing port (4 points)

Section 2.

- Correct placement of ports for accessing the urinary bladder (2 points)
- Straight incision (1 point)
- Watertight suture (3 points)
- Mucosa is included in every stitch (4 points)
- Complete imbrications (5 points)

Section 3.

- Good access (1 point)
- Correct primary stitches (2 points)
- Good placement of secondary stitches (3 points)
- Watertight anastomosis (4 points)
- No torn tissue (5 points)

Section 4.

- Good access (1 point)
- Correct primary stitches (2 points)
- Good placement of anterior and posterior suture (3 points)
- Watertight anastomosis (4 points)
- No torn tissue (5 points)

Section 5.

- Good access (1 point)
- Correct primary stitches (2 points)
- Good placement of secondary stitches (3 points)
- Watertight anastomosis (4 points)
- No torn tissue (5 points)
Section 6.
- Good access and retraction (1 point)
- Correct primary stitches (2 points)
- Good placement of secondary stitches (3 points)
- Watertight anastomosis (4 points)
- No torn bladder tissue (5 points)

Section 7.
- Good access (1 point)
- Correct primary stitches (2 points)
- Good placement of secondary stitches (3 points)
- Watertight anastomosis (4 points)
- No torn bowel tissue (5 points)
"D" MODULES

This program aims at familiarizing the student with the basic microsurgical techniques and the physical environment of the microsurgical operating room. This includes not only general improvement of dexterity, but also that of eye-hand coordination and economy of movements. By these steps, the students become capable of performing an anastomosis on a vessel in a 0.7–1.2 mm external diameter range.
D1. MODULE

Basic Microsurgical Skills

Site: Microsurgical skills laboratory

Procedures:
1. Position at the operative microscope
2. Hand and instrument positioning
3. Lacing a thread of a gauze net
4. Suturing a latex glove
5. Microsurgical knotting
6. End-to-end and end-to-side anastomosis on silastic tubes (external diameter 2 and 1 mm)
7. Vessel anastomosis ex vivo

Schedule

<p>| | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>L1 (180 min)</td>
<td>Introduction (theoretical, technical and clinical background)</td>
</tr>
</tbody>
</table>
| 2 | P1 (90 min) | 1. Position at the operative microscope  
2. Hand and tool positioning in microsurgery  
3. Lacing a thread of a gauze net |
| 3 | P2 (90 min) | Practicing the two-handed knotting technique macroscopically |
| 4 | P3 (90 min) | 4. Suturing a latex glove  
5. Microsurgical knotting |
| 5 | P4 (90 min) | 4. Suturing a latex glove  
5. Microsurgical knotting |
| 6 | L2 (120 min) | Anastomosis techniques—lecture |
| 7 | P5 (120 min) | 6. Suturing of silastic tubes (2 mm), end-to-end and end to side anastomosis, microsurgical knotting |
| 8 | P6 (120 min) | 6. Suturing of silastic tubes (1 mm), end-to-end and end to side anastomosis, microsurgical knotting |
| 9 | P7 (120 min) | 7. Vessel anastomosis ex vivo |
| 10 | E (60 min) | Evaluation, test |

Section 1.

Position at the operative microscope

Aims: Achieve a comfortable sitting position at the microscope: one should remove every object from the ground around the table legs. Sit with straight back, support your forearms on the table surface.

- Light intensity is set to minimum.
- Position the eyepieces at “0” dioptrier mark.
- Set the interpupillary distance.
- Adjust the approximate focus.
- Choose the lowest magnification and focus on the spot that you previously marked.
- Choose the highest magnification and adjust the fine focus for this magnification.
- Adjust the oculars for critical focus: separately for each eye, by rotating the lens of the eyepiece.

Section 2.

Hand and instrument positioning

Steps

- Only the wrist and fingers are to move during work and the lower arms should rest on a solid surface. This way we can avoid unnecessary, large movements and some of the tremor.
- The instruments are held like a pencil using three fingers, the thumb, the index and the long fingers. The elbows, the wrists and the ulnar sides of the forearms should rest on the table.
- The arms should form 60–90 degree angle with each other, so that the forearms are in a slightly supine position.

Section 3.

Lacing a thread of a gauze net

- Using two forceps, we remove a vertical thread from a gauze dressing (attached in a flat position on a board).
- Next we put it back into its original location in the net. Please note that you should use both right and left instruments for grasping the thread.
- Grab the thread as many times as necessary. The aim is to achieve a state where the previously removed vertical thread is indistinguishable from the rest of the net.

Section 4.

Stitching into a rubber sheet

Materials needed: 10/0–7/0 atraumatic needles, microsurgical forceps or fine tipped needle holders, rubber sheet.

- Loading of the needle: closer to the thread (at approx. 2/3 distance from the tip of the needle). Hold the thread by the left hand and lay the greater curvature of the needle on the surface in a way as it will get into position. Now grab it with an instrument held by the right hand.
- Entrance bite (stitch at the right side): The needle is held by the forceps in the right hand, the forceps in the left hand is put under the incision (to expose the wound on the right side). Never grab the edge of the structure to be sutured with the forceps. The axis of the needle should be perpendicular to the surface to be sutured. The distance from the edge should be approx. twice of the diameter of the needle.
- Exit bite (stitch at the left side): The tip of the needle should get out exactly in line with the entrance bite. When the needle is pulled through, surface friction should be countered by retracting the rubber with the left forceps (counter pressure).
Section 5.

Microsurgical knotting

Reminder: In case of a square knot two half hitches are placed on top of each other in an opposing manner. Microsurgical knotting involves the coordinated use of both hands, similarly to the laparoscopic or traditional instrument tie approach. Two methods of tying knots are used, the two-handed and one-handed versions, respectively. The one-handed knotting is similar to the method used in macroscopic instrument aided (apodactylic) knotting procedures, because the long part of the thread is held always in the same hand, (this is the “lazy” technique often resulting in slipping “granny” knots and multiple loops needed for secure hold). During the two-handed knotting procedure the thread is passed into the other hand, creating an easily repeatable pattern, economical effort and a small, secure knot. One should distinguish the two parts of the thread as 1. “long end” (to which the needle is connected) and 2. “short end” (which is the true end of the suture and resides on the right side after the stitching).

Two-handed knotting procedure

Directions: The clock face orientation (see below) is used in identifying locations and directions on the circular surface of tubular structures.

The first hitch
- Grab the long thread with the right needle holder at a distance which can be easily looped around the tip of the left forceps (direction: clockwise: towards the “short end”; distance: 3 times the length of the “short end”).
- Reach and pull the “short end” through the loop with the left forceps (meanwhile do not let the loop slip off).
- Pull only the “long end” while firmly holding the “short end”, and
- Tighten the knot.

The second hitch
- Move the “long thread” to the side of the short end.
- Grab the “long end” now with the left hand (distance: 3 times the length of the “short end”).
- Wrap it around the right forceps (direction: clockwise: opposite to the “short end”) then grab the “short end” with the right forceps and pull it through the loop.
- Tighten the knot. Eventually, cut both the “short and long” ends approx. 3 mm long.
Section 6.

Inanimate anastomosis models.

End-to-end and end-to-side anastomosis on silastic tubes (with external diameter of 2 and 1 mm)

Aims:  
- To practice anastomosis suturing in 3 dimensions  
- To learn the order of stitches in different vessel anastomoses

The stitching and knotting techniques are the same; the order of the 8 stitches is as follows:

- **Anterior surface:** 1st stitch is placed at 12 o’clock, 2nd stitch at 6 o’clock, 3rd stitch at 3 o’clock, 4th stitch at 1.5 o’clock, 5th stitch at 4.5 o’clock.
- The tube is rotated 180 degrees, hence the posterior surface comes into an anterior position.
- **Posterior surface:** the remaining 3 (6th–8th) stitches are placed at 3, 1.5 and 4.5 o’clock, respectively (see below).

![Anterior and posterior wall diagram]

## Section 7.

Vessel anastomosis ex vivo

This section involves the use of fresh tissue vessel material, enabling the student to learn tissue handling, stitching and knotting of a delicate tissue. The vessels are different in many characteristics from the silicone tubes, and from the live tissue. The vessels are flat and the walls are collapsed. It lets the student experience how big the bites should be to prevent overlap and how much force should be applied at microsurgical knot tightening as well as how the needle should be oriented to prevent the inclusion of the posterior wall. Vessels are taken from rats, frozen and thawed on the day of surgery.

### Steps
- The prepared vessel is placed on a moistened gauze sheet keeping it always wet in order to prevent drying out of the vessel wall.
- The isolated vessel is clamped with two microvascular clips (set in at least 6 mm distance) and cut through completely, perpendicularly to its axis.
- The loose adventitial fibers should be removed in few millimeter distances from the edges by teasing the fibers over the cut surface and pulling them beyond using forceps and trimming them in a circumcision style using microscissors.
- **Positioning of stitches:** Under both in vitro and in vivo situations, 8 stitches are used to suture the circumference (the same sequence is used as above).
- Check for water tightness and leakage.

### Positioning of stitches

Under both *in vitro* and *in vivo* situations, 8 stitches are used to suture the circumference. The top point is defined as 12 o’clock, and the lower as 6 o’clock.

#### The order of the stitches on a vessel when using an intraluminal stent

- **Anterior surface:** 1st stitch at 12 o’clock, 2nd stitch at 6 o’clock placed, and then insert a smaller diameter silicon cannula into the lumen. This may help to avoid the accidental stitching of the posterior wall. 3rd stitch at 3 o’clock, 4th stitch at 1.5 o’clock, 5th stitch at 4.5 o’clock.
- **Posterior surface:** 6th stitch at 1.5 o’clock, followed by a regular knot. 7th and 8th continuous suture consists of 2 steps:
  - stitch at 3 o’clock,
  - stitch at 4.5 o’clock. This enables us to remove the silicone cannula without the necessity of putting in further stitches.
- **Removal of the silicone cannula (stent).** First tie the upper loop, then cut it and finish with the lower loop. Check for water tightness and leakage.
Tie the upper loop, then cut it and finish with the lower loop.

Completed vessel anastomosis with 8 stitches.

Factors influencing the success of microvascular anastomosis:
- The adventitia should be carefully removed. Adventitia entering the reconstructed vessel lumen causes thrombus formation. If the stitch is placed only into the adventitia, incomplete seal will result.
- If the stitch is placed far from the edge of the vessel, or if the knot is very much tightened, the vessel edges overlap and this reduces the lumen.
- Do not stitch too deeply, to prevent inclusion of the posterior wall into the stitch. This can also be avoided if the needle is grabbed short.
- Utmost importance is the method of checking the passage of the needle after penetrating the anterior wall. The needle often sunk too deep and it may pick up the posterior or side wall with disastrous consequences. This can be avoided by turning the needle horizontal as soon as it has penetrated the anterior wall. One can also play with the needle by repeatedly lifting and pushing it down by a fraction of a millimeter. This way one can be assured that the needle rides freely without moving the posterior wall. This can be observed not only visually, but the force difference can be felt also (as the needle tip is lifting the posterior wall).
- Microsurgical stitches should be placed always faultlessly (to the right spot) for the first time, because repeated stitches make more holes and weaken the wall structure.

Evaluation

Section 1.
Position at the operative microscope is appropriate (10 points).

Section 2.
The instruments are held in a pen position during all procedures and elbows are supported (10 points).

Section 3.
Lacing a thread of gauze net is performed within an optimal time interval, the gauze net is not disorganized. Trembling is reduced (10 points).

Section 4.
Suturing of the rubber pad is performed within an ideal and equal distance from the incision. The stitches are performed in even distances. At least 10–10 stitches are performed into vertical, horizontal and right and left oblique incisions within 2 hrs (10 points).

Section 5.
Microsurgical knotting is perfectly performed within 30 sec. The direction of threads is perpendicular to the incision. Knots are not loose (15 points).

Section 6.
The student is able to apply the skills learned with planar stitching at 3 dimensional tubular structures. The order of stitches is correct; the distances are equal (20 points).

Section 7.
The student is able to overcome the capillary tension on the fine sutures, stickiness of the ex vivo vessels. Does not let the vessel dry out. The stitch bites are equal and the vessel anastomosis is patent. When the vessel is cut longitudinally, the stitch bites appear equally deep and always include the intimal layer (40 points).
D2. MODULE
Advanced Microsurgical Skills

During these procedures the students will be able to expose and suture vessels, prevent and handle bleedings. During these tasks the microscope has to be dynamically adjusted.

**Schedule**

<table>
<thead>
<tr>
<th>1st day</th>
<th>L1 (60 min)</th>
<th>Introduction (theoretical, technical and clinical background). Lecture (L)</th>
</tr>
</thead>
</table>
| 1st day | P1 (60 min) | 1. Position at the operative microscope  
2. Hand and instrument positioning in microsurgery  
3. (Lacing a thread of a gauze net) |
| 1st day | P2 (60 min) | 4. (Suturing a latex glove)  
5. Microsurgical knotting |
| 1st day | L2 (60 min) | Anastomosis techniques |
| 1st day | P3 (60 min) | 6. Suturing of silastic tubes (2 mm), end-to-end and end to side anastomosis, microsurgical knotting |
| 1st day | P4 (60 min) | 6. Suturing of silastic tubes (1 mm), end-to-end and end to side anastomosis, microsurgical knotting |
| 2nd day | P5 (360 min) | 7. (Vessel anastomosis ex vivo)  
8. End-to-end vessel anastomosis in vivo (carotid artery) |
| 3rd day | P6 (300 min) | 8. End-to-end vessel anastomosis in vivo (femoral artery)  
9. Anastomosis on nerves in vivo |
| 3rd day | E (60 min) | Evaluation, test |

**Site:** Microsurgical skills laboratory

**Procedures:**
1. End-to-end vessel anastomosis *in vivo*
2. Anastomosis on nerves *in vivo*

**Section 1.**

End-to-end and end-to-side anastomoses *in vivo*

**Steps**

- The most commonly used end-to-end models for arterial anastomosis are using the abdominal aorta, carotid and femoral arteries of the rat. For this purpose, rats weighting 350–400 g are anesthetized; the abdomen, the ventral side of the neck, and the internal sides of the inferior limbs are shaved.
- The animal is placed on the back; the limbs are immobilized with bandage strips.
- After making a skin incision between the mandible and the sternum, find the carotid artery medially to the sternocleidomastoid muscle. Place a retractor to each side of the wound. Identify the vagal nerve, separate it with forceps under the microscope, and free the artery from the surrounding connective tissue for approx. 2 cm long. Care should be taken not to injure the vagus or the internal jugular vein.
- Preparation of the femoral artery: After making a 3 cm-long groin skin incision, expose the femoral region and secure it with retractors laterally. Using a higher magnification, remove the fine layer of connective tissue that covers the tissues with 2 cotton swabs until the femoral bundle appears wrapped in the vascular sheath. First separate the femoral neurovascular bundle. Then the femoral artery is carefully separated from the vein. To overcome artery spasm, 2% lidocaine solution can topically be applied on the wound.

**Arterial end-to-end anastomosis of the rat carotid artery with 8 interrupted sutures (sec. Yonekawa)**

**Steps**

- After preparation of the vessel, background material is inserted under the dissected vessel.
- Place two approximator clips on the artery (first proximally then distally; so that there is about a 5 mm distance between the clamps) and cut it completely through with scissors perpendicularly to its axis.
- The lumen should be irrigated in both directions with a saline solution containing 100 U/ml heparin.
- The adventitia should be removed in a few millimeters from the edges (using forceps and scissors).
- Luminal stretching dilatation can also be applied to resolve vasospasm.

**The order of the stitches on a vessel**

- Frontal surface: (1) stitch at 12 o'clock, (2) stitch at 6 o'clock, (3) stitch at 3 o'clock, (4) stitch at 1.5 o'clock, (5) stitch at 4.5 o'clock.
- Dorsal surface: (6) stitch at 9 o'clock, (7) stitch at 10.5 o'clock, (8) stitch at 7.5 o'clock.

**Removal of the clips**

- Open the retrograde clamp first followed by the proximal one.
- Irrigate with normal saline (not containing heparin), suction away with a small gauze or cotton ball for 2–3 minutes until bleeding stops.
- If the anastomosis still bleeds, identify the source and place supplementary superficial sutures to stop it.

**Patency tests**

- Direct observation: transversal pulsation both cranially and caudally from the anastomosis.
- "Uplift test": Lift the vessel caudally to the anastomosis with forceps, until it collapses. It will pulsate, when lowered, if the anastomosis is patent.
- The "empty-and-refill test": Clamp the artery with a forceps immediately distal to the anastomosis, and then close the artery again with a second forceps, immediately near distally to the first one. Slide the second forceps over the
artery in the direction of the blood flow in a milking fashion, keeping it closed while releasing the first forceps. An almost instant filling of the emptied segment of the artery proves the patency of the anastomosis. Any delay is a sign that the anastomosis is partially blocked (involve ment of the adventitia in the lumen or to a through-stitch). If there is no filling and the vessel remains collapsed the anastomosis has completely failed.

- Opening the anastomosis: after ligating the repaired vessel both cranially and caudally, cut out the anastomosis, transect it longitudinally, opening it as a book and evaluate the internal aspects of the sutures underneath the operating microscope.

Section 2.

Anastomosis on nerves \textit{in vivo}.

Epineural approximation

- Preparation of the sciatic nerve: The gluteus maximus is split and the sciatic nerve is exposed and freed up.
- The nerve is cut with a sharp scalpel to avoid crushing injury to and mangling of the axons.
- It is recommended that a thin blue rubber dam (background) be placed beneath the nerve. The ends are then irrigated and debris carefully trimmed off.
- Trimming the axons: Proximally a mushrooming effect will occur as the axons extrude from their nerve sheaths. The protruding exoplasm must be trimmed off to create a straighter path for the regenerating axons. This excision should be performed on both ends of the nerve to the extent that short empty sleeves of nerve sheaths remain, resembling a vein.
- The first stitch: These stitches involve 8/0 or 9/0 sutures, and are placed under approximately 5× magnification using the operating microscope. The needle is driven from outside to inside through the epineurium, 1 mm from the cut ends of the nerve in a perpendicular fashion. Note that the needle should penetrate the epineurium, not the axons. The needle is then driven into the epineurium on the opposite end of the nerve, from inside to outside. The knot is tied with leaving tails approximately 2 cm in length.
- Second stitch: The second stitch is placed in the same manner, 180° from the first stitch.
- Subsequent stitches: The 1–3 additional sutures can be placed in between the first two stitches on the anterior surface. Using the tails of the first and second stitches, the nerve can be rotated 180° and another 1–3 sutures can be placed on the posterior surface. The nerve is then rotated back and the long stay sutures are cut.

Evaluation

Section 1.

At the end-to-end \textit{in vivo} vessel anastomosis, the final results should meet the requirements listed in Section 7 of D1 Module. In addition, the student should be able to prepare the vessel without causing any trauma and perform a patent anastomosis without considerable amount of bleeding. In the ideal case, the student is able to perform anastomosis of both carotid arteries in 2 hrs.

Section 2.

The student is able to prepare the sciatic nerve and to perform the anastomosis on the nerve \textit{in vivo} using epineurial technique. The completed anastomosis should not be under any tension whatsoever. Enough stitches are placed to eliminate excessive epineurial gaps and no protruding axons exist between stitches.

General mistakes:

- The student does not use both of his eyes under the microscope.
- Injures the instruments.
- Injures the structure ought to be prepared.
- Tears and looses the thread.