SHORT THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PHD)

Skill assessment methods for teaching surgical scrubbbing and suturing techniques

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The Examination takes place in Building A of the Department of Operative Techniques and Surgical Research, Faculty of Medicine, University of Debrecen; 5 December, 2017, 11.00 AM

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1. INTRODUCTION

Besides intellectual capacities, adequate technical knowledge is essential for professionals in the operative field. There is a subject or course available for medical students worldwide at the medical universities which aim is to teach basic surgical techniques that are useful for all physicians.

It also provides the opportunity for students to compare their own performances to that of the others, to face their own skills and limits. This may help to decide after graduating at the university to choose operative profession or internal medicine. In our country, education of basic surgical techniques is available at all four medical universities.

Certainly, the development must not stop at obtaining the medical degree. Technology is progressing rapidly today, new operative techniques, technologies come to light. It requires intensive and continuous learning.

At the Department of Operative Techniques and Surgical Research of the Institute of Surgery, Faculty of Medicine, University of Debrecen our aim is to teach essential (i.e. hemostasis, blood sampling, conicotomy, intravenous injection, surgical hand rub), useful (i.e. suturing and knotting techniques, suture removal) and informative knowledge (i.e. vascular and gastrointestinal surgery, minimal invasive surgery) for the future work of medical students during *"Basic Surgical Techniques"* compulsory course.

Timeliness, quality and applicability of the devices, models and simulators used in education are also important factors.

Surgical training is undergoing a paradigm shift, based on technological advances in health care. Technological progress brought into focus the use of surgical training and phantom models as well as simulators in health care to learn and train basic surgical techniques.

It is not ethical for medical students to gain experience on patients even when the patient consents. It is also not acceptable that the possibility to meet some surgical task or problem depends on chance for the residents.

Based on *Fitts and Posner's* three-stage theory of motor skill acquisition, at the beginning of the learning period the learner must understand the task by reading, seeing and listening, learns and develops strategies in the *cognitive stage*, translates the action into steps, i.e in case of tying knot thinks over the sequence of movements. In the *integrative stage* will practice a lot, makes first more then less mistakes. At that stage the motoric movements are settled but the learner is still thinking about how to hold and move the instruments and the hands. In the *autonomous stage* the performance is smooth, movements are trained, fluent, settled and do not need concentration. The learner can concentrate on other aspects of the procedure.

This theory has important role in surgical education. In view of the process, it is clear why is it important for the students that relieved from the stress of the reality of the operating theatre to be free to concentrate on the given task, control movements, do atraumatic work, repeat it several times and pose questions.

To meet these needs, surgical education today is unimaginable without training devices and simulators.

In our study, we focused on the objective analyses of two important basic skills such as surgical hand rub and taking simple interrupted stitches in suturing techniques. The reason for the choice was that the knowledge of these skills is essential for all who does operative profession and is useful for every medical doctor. Therefore, we consider it as milestones of medical and surgical education.

2. AIMS

Concerning the two investigated topics, our objectives were as follows:

2.1. Evaluation of surgical hand rub

1. We aimed to monitor the efficacy of the surgical hand rub among 3rd-year medical students using UV-test method in order to identify the critical regions and analyse the mistakes with special emphasis to the number of the students who had made mistakes, the number and extension of the missed spots on the dorsal and palmar sides of the hand.

2. We wanted to gain data about the possible differences with regards to right and left handedness and gender.

3. We aimed to summarize our technical experiences during the surveys in order to contribute to later infection control examinations in the clinical practice to improve patients' safety.

2.2. Evaluation of simple interrupted stitches

1. We aimed to monitor the performance of 3rd year medical students during their basic surgical techniques studies in the basic and the consecutive elective course, with regards to the time required for the task and the quality of it based on a modified international score system. We aimed to set categories – average, above and below average- based on the time result.

2. Our objective was to measure the development of the students during a class, during the course and between the courses.

3. We aimed to analyse the students' performance with regards to gender, right and left handedness and examine if the interest in surgery and previous activities may influence their performance.

3. MATERIALS AND METHODS

3.1. Evaluation and surgical hand rub

Teaching surgical hand rub is part of the 15-week curriculum of the *„Basic Surgical Techniques”* compulsory course announced for the 3rd-year medical students of the Hungarian and English Program at the Faculty of Medicine of the University of Debrecen.

On the 4th week of the course a 45-minutes lecture reviews the history, importance, principles of asepsis-antisepsis, proper technique and suggested products of the surgical hand rub. On the same week, a 2-hour practical training is conducted in small groups (6-7 students per one tutor) where the students trained on proper technique. Afterwards each student will perform the surgical hand rub procedure under the supervision of the tutor not only on that 4th week but also several times during the semester. Demonstration of the technique is also part of the practical exam.

The survey was conducted on the 10th (Survey 1) and 14th week (Survey 2) of the *“Basic surgical techniques”* compulsory course in the 1st semester of the 2013/2014 academic year with the participation of 285 3rd-year medical students. 32 students were excluded from the study: 19 because of being absent from either of the surveys and 13 for improper position of the fingers (laid over one another) which made the evaluation of the photos impossible.

From the 253 participants there were 100 male and 153 female students, among whom 230 were right-handed (88 male and 142 female) and 23 left-handed (12 male, 11 female)

Students were asked to perform surgical hand rub according to the recommendations of the World Health Organization defining 5 crucial steps. After hand wash, rinsing and drying Skinman Soft N (Ecolab - Hygiene Ltd., Hungary) was used four times and in the 5th minute a fluorescent solution for education purposes (Schülke Optic, Schülke & Mayr GmbH) was applied that

is fluorescing under UV-lamp. Afterwards the hands had to be placed into a special box with 3 UV-light bulbs inside (Schülke Optics UV Schülke & Mayr GmbH). Photos were taken from the dorsal and palmar side of the hands with Canon Powershot SX40 HS device. To achieve the best lighting of the hands they have to be set into central position along the horizontal and perpendicular axis, respectively and care must be taken not to exceed the edge of the glass rooftop of the box from top view. The analysis was performed by Adobe Photoshop CS6 program with 1984x1488 pixel images. In the presence of the fluorescent solution, fluorescing can be seen while the uncovered areas appear as dark spots. The examination was performed under moderately intensive diffuse background lighting conditions. Photos were taken in upright position from the backs and palms of the hands with spread fingers.

The dorsal and palmar surface of the hand was defined individually as 100% and the uncovered areas (determined as mistakes) were expressed in percentage of that. Both the number of the students who made mistakes, the number, size and localization of the missed spots were evaluated based on the pixel numbers with regard to right/left handedness and sex. The differences in the intensity could be also relevant but in the present study according to the definition that every area uncovered by UV was a mistake, we investigated only the presence of the missed spots. The areas were defined in pixels.

In order to classify the mistakes, the hand was divided into regions indicating identical points both on the dorsal and palmar surface of the hand. Region 1 means the distal phalanges of the fingers, Region 2 the thumb and the 1st metacarpus, Region 3 the middle and proximal phalanges of 2nd to 5th fingers and Region 4 the 2nd to 5th metacarpals closed with the carpal bones.

3.1.1. Statistical analysis

For the statistical analysis of the evaluation of the surgical hand rub, procedure χ^2 test was used to compare the results of Survey 1 and 2. For

comparison of male and female, right and left hande students Student t-test or Mann-Whitney Rank Sum tes was used based on the data distibution. To analyse the number and size of missed spots paired t-test or Wilcoxon test was used, $p<0.05$ was chosen to indicate a significant difference.

3.2. Evaluation of simple interrupted stitches

The measurements were carried out during the 15-week *"Basic Surgical Techniques"* compulsory course (15 lectures, 15x2 hours practices) for 3rd year medical students in the 1st semester of the 2012/2013 academic year (Survey 1) and the *"Surgical Operative Techniques"* consecutive required elective course (4 lectures, 4x2 hours pratices) for 3rd and 4th year medical students in the 2nd semester of the 2012/13 academic year (Survey 2) of the undergraduate medical education, at the Department of Operative Techniques and Surgical Research of the Institute of Surgery, Faculty of Medicine, University of Debrecen.

In the first survey 152, in the second survey 27 out of the 152 medical students participated.

In case of the compulsory i.e. basic course the aim is to acquire basic knowledge (surgical instruments, basic suturing and knotting techniques, surgical hemostasis, injection techniques and blood sampling, scrubbing), to learn life-saving procedures (conicotomy, tracheostomy) and to get an insight into the basic principles of laparotomies, intestinal, vascular and parenchymal organs' surgery, minimal invasive techniques). Besides, the students become acquainted with ancillary materials used in surgery (surgical suture materials, bioplasts, tissue adhesives).

"Surgical Operative Techniques" course is announced for students who are particularly interested in surgery. It aims evoking, deepening, extending and training of all knowledge acquired in *„Basic Surgical Techniques"* course.

Before the survey, the participants filled a questionnaire on gender, dominant hand, and specific interest in manual professions, hobbies that presume better manual skills or have a potential positive effect on it (e.g., playing musical instruments, craftwork, fine arts, and computer games).

The students got the necessary theoretical knowledge during the first 3 lectures of the *"Basic Surgical Techniques"* course and received detailed practical demonstration in the 3rd week of the course about suturing and knotting techniques. During the testing module, the students took simple interrupted stitches, either into 3-layer professional skin pad or into porcine biomodel (i.e. porcine feet) with the assistance of another student, whose role was to hold the end of the thread and pass the scissors in time to cut the thread after tying the knot. The same student who took the stitch tied the knot.

The plastic model was 125x72 mm in size, 3 layers synthetic skin pad having soft skin layer with a similar drag and strength to human skin and comprising epidermis, dermis and subdermal layer. It was positioned into a jig that is a flexible plastic pad (Limbs & Things Ltd, UK, distributed by Speeding Kft, Hungary). The biomodel was porcine foot, purchased and used according to the permission of the Hajdu-Bihar County Food Chain Safety and Animal Health.

The necessary instruments (surgical forceps and Mathieu needle-holder with suitable needle and thread) were chosen and prepared by the student her/himself.

The amount of time to take a stitch into the model and fix it with surgical knot tied by two-hand technique was measured by chronometer. The duration of the whole process was measured from the moment when the tip of the needle came into contact with the model, holding the appropriate instruments in hand, to the moment when after having pulled the needle through the tissue, surgical knot had been tied and the thread had been cut. The sutures

were carried out with polyesther thread (Tervalon), using 2-0 for the biomodel and 3-0 for the plastic skin model.

The skin pad measurements were carried out in the 5th week of the course, in the seminar room (moulage in the seminar room-MSR) and in the 8th week, in the operating room (moulage in the operating room-MOR). The elective course measurements were performed in the 1st week of the course in the seminar room (MSR) and in the 3rd week in the operating room (MOR). The biomodel (porcine feet) measurements were performed in the 4th and 14th week of the basic and in the 2nd and 4th week of the elective course, each time in the operating room (biomodels in operating room BOR I, BOR II). It should be noted, that during the 15 occasions of the basic and 4 occasions of the consecutive elective course the students had the opportunity to practice suturing week by week, several times during the classes.

The 'dry' seminar room measurements were carried out at a table in sitting position, without gloves, wearing casual clothes, while during the operating room measurements the students were standing at the operative tables, wearing operating room clothing (surgical gown, mask and gloves).
On each occasion, there were two testing modules, namely one at the beginning and the other at the end of the practical class. In the meantime, the students had enough time to practice the task minimum 5, maximum 7 times. The improvement was checked by comparison of the two values. In order to analyze the development during the course and between the basic and consecutive elective courses the average values of the initial and final measurements were used.

The original checklist comprises a series of yes/no items that were framed by Reznick, varied later by Boros et al, and involved 18 aspects. In our evaluation aspects, five items had been modified. Three items were excluded: is needle grasped with fingers or not, the distance of the stitches are 0.5 -1 cm, the stitches are intermittent or not. Five more points were added: 1. the stitch starts from the far

end of the wound, 2. protection of the point of needle, 3. spherical knot. Two more items had been added: leaving correct length of the thread above the knot and dynamic work. The maximum score was 20. An experienced tutor evaluated the implementation.

Based on the results, according to the time required for the sutures the students were divided into 3 categories based on the quartiles: below average (lower quartile <25%), average (interquartile range 25-75%) and above average (upper quartile >75%). It was done both at the beginning and at the end of each class.

We have also examined whether there is any difference between the students related to gender, right or left-handedness, former activities or hobbies that may improve or presume better manual skills and interest in surgery. The comparison was based on the classification into the above-mentioned three categories and the values of the final biomodel measurements were used.

3.2.1. Statistical analysis

The Kolmogorov-Smirnov test assessed normality of the data. The Friedman test was used to assess significant differences in quantitative variables at each of the all follow-up courses. Comparing the time and the quality of suturing Spearman rank correlation, for evaluation the results Wilcoxon-test was used $p<0.05$ was considered as statistically significant.

4. RESULTS

4.1. Evaluation of surgical hand rub

4.1.1. Number of students who failed the assessment and number of missed spots per student

Detection of minimum one missed spot occurred in 123(48.6%) (69 female, 54 male) students in Survey 1 on the 10th week of the course while only in 65(25.7%) (33 female, 32 male) in Survey 2 on the 14th week ($p<0.001$).

The number of students with unsatisfactory surgical hand disinfection was significantly lower in Survey 2 compared to Survey 1 25(9.9% of all) (13 female, 12 male) from these 65 students made mistake only in Survey 2 while 40(15.8% of all) failed the test both times.

There was no significant difference in the number of the missed spots per student. In Survey 1 2.87±0.21 and in Survey 2 3.03±0.26 missed spots were detected, but the maximum number of the uncovered areas per student decreased from 14 (10th week) to 10.

4.1.2. Size of the missed spots

There was no significant difference there. On the right dorsal side the extent of the untreated area was 3.02±0.45% on 10th week and 2.27±0.51% on 14th week, while on the left dorsal side it was 1.81±0.36% and 0.96±0.17%, respectively. On the right palmar side, it was 1.72±0.17% in Survey 1 and 1.67±0.13% in Survey 2, on the left palmar side it was 1.32±0.18% and 1.24±0.16%.

4.1.3. Dorsal vs palmar location of the missed spots

In Survey 1 significantly more missed spots were found on the dorsal side (157 vs 94), while the opposite was seen on palmar side (72 vs 45).

The number of the students making mistakes on the dorsal side decreased significantly (157 vs 45), while it was not significant on the palmar side

(94 vs 72). The number of the students making mistakes on the right dorsal side decreased significantly from 94 to 25 in Survey 2 similarly to the left dorsal side (63 vs 20 students, $p<0.001$). Concerning the right and left palmar side there was no significant difference between the tests (59 vs 43 and 35 vs 29).

4.1.4. Location of the mistakes by region

In Survey 1 the most number of the missed spots was found in D2 region what was the thumb and the 1st metacarpus: 59 spots on the right hand and 36 on the left hand. Another critical area was the P4 region with 62 spots on the right, and 38 on the left hand where many spots were on the proximal part of the palm.

In Survey 2 several untreated spots were observed in D1 region (distal phalanges), mostly in the vicinity of the nail beds: 21 spots on the right and 17 on the left hand. The most critical area similarly to Survey 1 was the P4 region, especially at the proximal part of the palm with 61 spots on the right and 35 on the left hand.

4.1.5. Result of right vs left handed students

Right-handed students made fewer mistakes on their non-dominant left hand both on dorsal and palmar relation. In Survey 1 78 spots were detected on the dorsal side of their left and 134 on the right hands while 39 vs 66 spots on the palmar side. In Survey 2 our findings were 31 vs 54 on the dorsal side and 37 vs 61 on the palmar side. There was a significant improvement concerning the dorsal side to the 14th week that was not seen in the palmar side.

Concerning the size of the missed spots, we found significant difference. In case of the right-handed students, they were smaller on the left hand dorsal side than on the right hand: 1.88±0.4% vs 3.11±0.49% ($p=0.64$) in Survey 1, and 0.91±0.18% vs 2.38±0.59% ($p=0.51$) in Survey 2. There was no similar tendency in the left-handed students.

The percentage of missed spots of the students who made mistakes on the dominant hand was 29.3% in the Survey 1 and 20.8% in the Survey 2, and on the non-dominant, it was 30.3% in the Survey 1 and 19.59% in the Survey 2.

4.1.6. Sex differences

In Survey 1 54 male (54%) and 69 female (45%) had been found to perform unsatisfactory hand washing. The number of faulty rub procedure decreased significantly in females ($p<0.001$): while in Survey 2 only 32 male (32%) and 33 female (21.6%) students made mistakes. Female participants had better results, and they showed greater improvement. Even the number of the missed spots per female students showed a slight decrease (from 3.19±2.82 to 3.12±2.25) while the opposite was seen in male participants (from 2.37±1.50 to 2.94±2.02). Although in male students less missed spots were found, but their size were greater in both tests on both sides of the hands.

There was no significant difference with regards to the area of the missed spots between males and females. Not significantly, but the size of the missed spots was slightly larger on the right dorsal and left palmar side in male students and on the left dorsal side in female participants in both surveys.

4.1.7. Experiences during the measurements

The main advantage of the method is the prompt result. The intensity of the UV-marked solution was sufficient. Moderately intensive, diffuse background lighting provided the best condition for adequate visualization. Both much light and total darkness made the distinction between missed (dark) spots and shadows difficult or even impossible.

Since in the box UV-light comes from three sides, in some cases inappropriate position of the hands led to a shadowing effect especially at the proximal part of the palm and in the folds. These photos were excluded from the evaluation. The soap remnants also made the assessment more difficult.

4.2. Evaluation of simple interrupted stitches

In the first survey 152 (58 males, 94 female), in the second survey 27 out of the 152 (11 males, 16 female) volunteer medical students participated. In Survey 2 only those students took part who registered for the elective course as they were interested in surgery.

4.2.1. Quantitative assessment

During the weekly practices, two measurements were carried out with each student. Compared the results of the measurements at beginning and at the end of the class, both in "*Basic Surgical Techniques*" and "*Surgical Operative Techniques*" courses there were a definite improvement in the time required for taking a stitch both on synthetic and on biomodel.

Changes during one class

As for the basic course, the time required for taking stitches into the skin pad, in the seminar room significantly decreased on the 5th week: 78.4±15.3 s vs 71.5±15.2 s ($p<0.001$) as well as on the 8th week in the operating room: 86.6±15.9 s vs 79.6±16.1 s ($p<0.001$).

On biomodel, in the operating room the same was seen: on the 4th week 76.5±14 s vs 70.9±13.9 s ($p<0.001$), on the 14th week 69±14.6 vs 63.9±14.1 s ($p<0.001$).

As for the basic course, taking stitches on synthetic model took significantly less time: on the 1st week, in the seminar room: 58.1±7.3 vs 54.1±6.4 s ($p<0.001$) and on the 3rd week in the operating room: 60.4±7.8 s vs 56.3±6.6 s ($p=0.003$). On biomodel the same was found: on the 2nd week: 59.1±5.9 vs 54±5.8 s ($p=0.006$) and on the 4th week: 4.9±8.6 vs 49.9±6.1 s ($p=0.049$) both measured in the operating room.

Changes during the course

We compared the average time results, calculated from the results of the measurements at the beginning and at the end of the class. In case of both courses, the first and last week measurements were compared. The models were the same

(biomodel) during the basic and different (skin and then biomodel) during the elective course.

Over the length of the course (from 4th to 14th week) in *"Basic Surgical Techniques"* significant improvement was found: 73.7±13.8 s vs 66.5±14.3 s ($p<0.001$), these values were measured on biomodels. With synthetic models (from the 5th week to 8th week), an unexpected, significant increase was found: 74.9±14.5 s vs 83.1±15.4 s ($p<0.001$). It should be noted, that the 5th week measurement was carried out in the classroom while the 8th week measurement in the operating room. Only 3 weeks passed between the two measurements but it was10 weeks in case of biomodels (4th and 14th week).

In the consecutive elective courses the average time of taking stitches decreased significantly from the 1st (on synthetic model) to the 4th week (on biomodel) of the course 56.1±6.8 s vs 52.4±7.3 s ($p=0.016$). Checking the synthetic model only, it was surprising that the average duration mildly increased from the 1st week (in the classroom) to the 3rd week (in the operating room) 56.1±6.8 s vs 58.4±7.2 s ($p=0.137$). On biomodels, the time had decreased (from 2nd to the 4th week, both in the operating room): 56.6±5.8 vs 52.4±7.3 s ($p=0.026$).

Changes between courses

Comparing the average time required for the stitch during the basic course and the consecutive elective course, we found significant difference between the similar measurements of the trainings: S-CR basic (74.9±14.6) vs S-CR elective (56.1±6.8 s); S-OR basic (83.1±15.4) vs S-OR elective (58.4±7.2); B-OR basic (73.7±13.8) vs B-OR I elective (56.6±5.8) and B-OR II basic (66.5±14.3) vs B-OR II elective (52.4±7.3) (in all $p<0.001$). It is worth to mention that the development during the basic course (from 4th to 14th week) was 11.2%; during the elective course (from 1st to 4th week), it was 7%. Friedman test showed significant improvement compared the time results of the basic and elective course (S-CR, S-OR, B-OR I, B-OR II).

4.2.2. Qualitative assessment

According to our score-system during the basic course the average value working on synthetic model in the classroom (S-CR) was 13.6±1.4 points (max. 20 points) and 16.4±1.2 points under operating room circumstances (S-OR), while working on biomodels in the operating room it was 13.1±1.5 points in case of the 1st (B-OR I) and 17.9±1.4 points in the 2nd measurements (B-OR II).

The results of the consecutive elective course were: 14.5±1.2 points (S-CR), 16.9±1.4 points (S-OR), 13.9±1.5 points (B-OR I) and 18.5±1.4 points (B-OR II). In the elective course, the students got more points than in basic course, but between the courses, no significant difference was found.

Working on synthetic model most of the problems were concentrated to the following areas: 1. the angle of the needle is 90° to the skin (piercing the skin with the needle at a 90° angle and rotating (supinating) the needle holder when the needle is driven through the tissue); 2. the model pad remains in place during the procedure; 3. security of the knot (not tight, not loose). In case of biomodels, the problems were somewhat different: 1. dynamic work (effortless flow from one move to the next); 2. identical distance from the wound edges on both sides; 3. stitching carried out with a flick of the wrist. Making proper knots was a problem in both courses. Similar to the duration of the sutures, the quality of work was also poorer when the students worked in the operating room for the first time.

In general, the values had an increasing tendency in both courses, although they were far from the maximum, so there had still been room for improvement.

Spearman analyses have not shown correlation between time results and quality.

4.2.3. Development expressed in category change

For further evaluation, we created three categories based on the duration of the sutures below average (BA), average (A) and above average (AA). The leap from BA to AA category was considered the most remarkable improvement, but also moving from BA to A or from A to AA category was also considered an improvement.

In the basic course on skin model on the 5th week 96 students (63.2%) belonged to A, 42(27.6) to BA and 14(9.2%) to AA category (152 in all). 28(18.4%) students leapt category: 15 from BA to A, 12 from A to AA and 1 from BA to AA.

Measured on synthetic model at the beginning of the practice on 8th week, in the operating room 75(49.4%) students belonged to A, 66(43.4%) to BA and 11(7.2%) to AA category. To the end of the practice 47(30.9%) students stepped into higher category: 29 from BA to A, 16 from A to AA and 2 from BA to AA.

Measured on biomodel at the beginning of the practice on 4th week, in the seminar room 72(47.4%) students belonged to A, 73(48%) to BA and 7(4.6%) to AA category. To the end of the practice, 21(13.8%) students stepped into higher category: 14 from BA to A, 5 from A to AA and 2 from BA to AA.

At the beginning of the 14th week 72(47.4%) students belonged to A, 43(28.3%) to BA and 37(24.3%) to AA category. In the end 32(21%) stepped higher: 10 from BA to A, 20 from A to AA and 2 from BA to AA.

All over the curriculum of the basic and the elective course there has been a steady progress. More and more students leapt one or even two categories, which meant that there were more above average and less below average students among the total number of them.

The advance was apparent during each class (from the beginning to the end) and also over the courses. While on the 4th week only 14(9.2%) students belonged to AA, at the end so many as 59(38.8%).

At the end of the elective course, in which each student was interested in surgery, nobody belonged to below-average category and 21(78%) from the total 27 got the above-average qualification.

4.2.4. Differences based on gender, dominant hand, positive past record and interest in surgery

The distribution of female and male students by average, below average and above average categories in "*Basic Surgical Techniques*" course was as follows: at the and of the course 19(20.21%) female students belonged to BA, 38(40.43%) to A and 37(39.36%) to AA category (total 94), 11(18.97%) male students to BA, 25(43.1%) to A and 22(37.93%) to AA (total 58). Compared to the beginning of the course 21 out of 94(22.34%) female and 11 out of 58(18.97%) male students showed progress by leaping categories. There was practically no difference in genders.

In case of the elective course there were neither female nor male student in BA, 4(25%) in A and 12(75%) in AA category out of the 16 female students and 3(27.27%) in A and 8(72.73%) out of the 11 male participants. It was very similar to that of the basic course. Altogether 9(56%) female and 7(64%) male students showed progress by leaping categories, which is higher rate than that of the basic course and indicates higher proportion of progress in males.

We also wanted to check the difference between right and left-handed students. At the end of the basic course 28(20%) right-handed students belonged to BA, 58(41.43%) to A and 54(38.57%) to AA (total 140) while 3(25%) left-handed one belonged to BA, 4(33.33%) to A and 5(41.67%) to AA (total 12). Therefore, there was no significant difference concerning the dominant hand.

In the elective course neither right (total 22) nor left-handed (total 5) students belonged to BA, 5(22.73%) right-handed and 1(20%) left-handed was in A and 17(77.27%) right-handed and 4(80%) left-handed in AA category. There was no significant difference.

Among students who had a specific past record concerning assumed manual skills (playing musical instruments: 50, craftwork/fine arts: 58 and playing computer games 76 students and some of them do simultaneous hobbies) the distribution was as follows:

With positive past record 7(10.44%) students were in BA, 22(32.84%) in A and 38(56.72%) in AA category (total 67). Without such antecedents 24(28.24%) to BA, 40(47.06%) to A and 21(24.7%) to AA category (total 85), so significantly more students belonged to AA category from the students with previous positive record.

During the consecutive elective course, where all students had a special interest to surgery (playing musical instruments: 25, craftwork/fine arts: 12 and playing computer games 27 students, with overlaps), 6(24%) was in A, 1(4%) in BA and 18(72%) in AA category, while without such hobbies 2(100%) belonged to BA category.

In the elective course, 72.2% of the students developed compared to the basic course. There was no change in 25% and deterioration was found in 2.8% of them, while in the basic course 25.7% showed progress, in 60.5% there was no change and 13.8% worsened. Time results were significantly better, the scores slightly better in the elective course.

5. DISCUSSION

5.1. Evaluation of surgical hand rub technique

Providing aseptic circumstances is essential for any surgery. For the members of the operative team surgical hand rub is crutial. Learning of it is key part of the education of surgeons and operative staff.

In our study, we aimed to assess the efficacy of the UV-test method among 3rd year medical students. This method has been used for the control of hygienic hand wash for a long time. The main advantage of this method was the ability to face the students promptly with their mistakes. Missed spots are well visible, the extension, the number and location, too. It provides guidance on what they should be looking for.

As we expected, the number of students making mistakes significantly decreased during Survey 2 but was still far from ideal.

The fact that 40 students had problems in both surveys and 25 students who passed the first test failed the second one, is perplexing, and would suggest that these students might be in lack of responsible attitude. As a possible explanation is that the interventions took place not on living organisms but on *ex vivo* models where no surgical site infection or any other complications may develop. The tutor paid special attention to these students: they revealed the technical problems and deficiencies; the teacher enhanced the motivation and pointed out the responsibility. It is interesting that more females performed the procedure properly and showed greater improvement 89.43% (Survey 1) and 92.3% (Survey 2) of the participants is right-handed that is similar to the findings of other authors. Our hypothesis that right-handed persons are more effective in surgical hand rubs on their left hand and conversely, was proven. Confronting the errors can prove the compliance.

The UV-test method is suitable for that: easy to use, has low costs and is time-consuming even on great number of students.

Based on the experiences of the survey, monitoring the efficacy of the surgical hand rub by UV-test is part of the practical exam of "*Basic surgical techniques'* subject from the 2015/2016 academic year.

5.2. Evaluation of simple interrupted stitches

In the gradual medical education there is a strong need for teaching basic surgical techniques. It belonges to the medical intelligence and without this knowledge students will not be able to take active and qualitatively acceptable part in surgical practices.

In Hungary, teaching basic surgical techniques is part of the curriculum at all four medical universities with similar tematics.

During the measurements, two different methods were applied: a low-reality synthetic moulage model (skin pad) and a porcine biomodel (pig feet). The time required for taking simple interrupted stitches and the quality of the work were assessed during *"Basic Surgical Techniques"* compulsory course and the *"Surgical Operative Techniques"* consecutive required elective course in order to reveal and assess the skills of the students and their development during the courses. Besides, we aimed to analyse their performance with regards to gender, handedness, and interest in surgery and free-time activities that may improve manual skills. For qualitative evaluation, the task-specific part of the OSATS system was used without the global rating scale. It was adapted to our teaching method.

To our expectations distinct improvement was seen both durin one class, during the courses and between the basic and the elective course. The time required for suturing and knotting significantly decreased in all cases. Based on the categorization (average, below/above average) that was based on the time required for the stitches, more and more students belonged into

above average category. During the elective course, the progress was even more remarkable. While the ratio of the above average students was 39% in basic, it was 78% in the elective course. A downturn was seen in the 8th week of the basic course that was possibly due to the unusual operative circumstances and the fact that it was a new challenge to share attention between works and keep steril circumstances.

Quality scores improved during both courses. Performance was smoother, movements more coordinated with fewer mistakes. There was no significant difference between basic and elective course.

There was no correlation between the time results and the quality improvement. Although no significant difference was detected with regards to gender and handedness, free time activities had positive effect on the results. Among these students, significantly more belonged to above average category. Similar findings were seen in case of students with special interst in surgery.

Similar to other authors, we are on the opinion, that the key factor for surgical skills improvement is the careful design of the curriculum, in the other hand an adequate model, using which students can learn and train the given task. We are sure, that besides the positive effect of the training the objective evaluation also contributed to the development of the students.

We aimed to monitor two basic skills: surgical hand rub and taking simple interrupted stitches in gradual medical education. We hoped to provide useful information for further work by evaluation of the skills of medical students at the beginning of their education and to follow-up their progress during further studies.

For effective teaching work, several factors are required: carefully designed curriculum, various models for different tasks, including synthetic, phantom and biomodels and last but not least individual teaching in small groups.

6. MAIN RESULTS AND CONCLUSION

6.1. Evaluations of surgical hand rub

1. To our knowledge in Hungary we were the first to evaluate the effectivity of surgical hand rub in case of medical students at the University of Debrecen, in the 1st semester of the 2013/2014 academic year, using UV-test to identify critical areas and to analyse the mistakes.

2. With statistical analysis we not only confirmed the literature data about common deficiencies in surgical hand rub, but also provided data on the number of the students who had made mistakes, the number and size of the missed spots concerning the sides and regions of the hands.

3. We concluded that the number of the students who made mistakes, significantly decreased, while the missed spots per student did not change significantly as did not the total area of the missed spots either.

4. Training of the surgical hand rub results in significantly less mistakes on the dorsal side of the hand. This was not true for the palmar side.

5. We confirmed the difference in surgical hand rub between right and left-handed students and the gender differences in making mistakes.

6. Our experiences during the survey provide data to the education of surgical hand rub technique as well as to the infection control investigations in the clinical practice.

6.2. Evaluation of simple interrupted stitches

During the measurements of the subsequent courses of *"Basic Surgical Techniques"* compulsory and *"Surgical Operative Techniques"* required elective course we concluded that:

1. As novel finding the positive effect of the subsequent courses on the development of the performance was clearly demonstrable. We were the first to prove that the time required for taking a simple interrupted stitch significantly decreased during one class, during the course and between the basic and elective courses. As an exception, the time taken for the task increased in the 8th week of the basic course, when students worked on the same model, but in the operating room. Deterioration could be attributed to the change in circumstances.

2. In the quality assessment it was found that student were far from the maximal scores. A downturn in quality, too, was seen in 8^{th} week. Different typical mistakes arose with synthetic and biomodel.

3. It was confirmed that training on models known from the literature lead to fast and effective acquisition of the skills. Categorization of students based on the time results demonstrated improvement proved by category change in more and more students. There was no correlation between improvement in quality and time results.

4. No significant difference was found with regards to gender and handedness. Free time activities that may improve the manual skills and interest in surgery had positive effect on the performance.

5. The qualitative and quantitative measurements gave possibility for assessing manual skills easily for individual and more effective teaching in order to improve skills.

We can conclude that the applied objective methods were suitable to evaluate the performance of the students, to reveal the problems and monitor the individual skills. It can help our education, the assessment during exams and the individual teaching in the future, too.

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Subject: PhD Publikációs Lista

Candidate: Erzsébet Ványolos
Neptun ID: ENW9SK
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List of publications related to the dissertation

1. **Ványolos, E.**, Furka, I., Mikó, I., Viszlai, A., Németh, N., Pető, K.: How does practice improve the skills of medical students during consecutive training courses?
   Acta Cir. Bras. 32 (6), 491-502, 2017.
   DOI: http://dx.doi.org/10.1590/s0102-865020170060000010
   IF: 0.729 (2016)
2. **Ványolos, E.**, Pető, K., Viszlai, A., Mikó, I., Furka, I., Németh, N., Orosi, P.: Usage of Ultraviolet Test Method for Monitoring the Efficacy of Surgical Hand Rub Technique Among Medical Students.
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List of other publications

3. Mikó, I., Németh, N., Somogyi, V., Kiss, F., Tóth, E., Pető, K., Furka, A., **Ványolos, E.**, Tóth, L., Varga, J., Szigeti, K., Benkő, I., Oláh, A., Furka, I.: Comparative erythrocyte deformability investigations by filtrometry, slit-flow and rotational ektacytometry in a long-term follow-up animal study on splenectomy and different spleen preserving operative techniques: partial or subtotal spleen resection and spleen autotransplantation.
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Clin. Hemorheol. Microcirc. 57 (3), 243-253, 2014.
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