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EDUCATION

Trial integration of combined ultrasound and laparoscopy tuition in an undergraduate anatomy class with volunteer participation — A pilot study☆

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ABSTRACT

Anatomy is a cornerstone of medical undergraduate curricula. Due to increasing changes in various medical fields, a lot of new subjects were introduced in undergraduate curricula, while the teaching areas of basic sciences, i.e. anatomy, were reduced. The introduction of advanced diagnostic and therapeutic devices, i.e. ultrasound and laparoscopy, with outstanding imaging quality will be increasingly introduced in basic sciences. In our project, we examined the effect integrating ultrasound and laparoscopy in an anatomy undergraduate course to illustrate the female pelvis. Anatomy students that completed their practicum and cadaver dissection course were enrolled in our project. They received a theoretical introduction followed by a practical course of ultrasound or laparoscopy in the department of obstetrics and gynaecology. Following the course the students had to answer two questionnaires that evaluated their satisfaction, subjective knowledge-gain, problems and content of the course. At the end, a closing briefing was done to discuss the clinical skills and the course. The answers of the questionnaire were summed up in a Likert scale. 25 students were enrolled in the project. 52% attended laparoscopy operations, while 48% attended ultrasound examinations. After analysing the questionnaires using Likert scales (1 = strongly agree, 5 = strongly disagree) a general satisfaction of 1.5, a subjective knowledge gain of 2.4 and a thrive to extend these clinical skill programs in gynaecology and other specialities in basic science of 1.5 and 1.2, respectively, was reported. There were no statistically significant differences in the Likert scores between both groups ($p > 0.05$). The introduction of ultrasound and laparoscopy in undergraduate basic science teaching programs is a promising method and should be further evaluated, standardized and expanded.

1. Introduction

Human anatomy has been a cornerstone of medical undergraduate curricula for decades and a basic science needed by all physicians throughout their career (Turney, 2007; Peterson and Tucker, 2005). The development of new significant sciences, the introduction of new technologies and the subsequent exponential growth of the spectrum of knowledge required in the field of medicine, have all contributed to a global reduction in the time allocated to anatomical undergraduate studies (Sritharan, 2005; Shaffer, 2004; Drake et al., 2009). The resulting deficiencies in the anatomical background knowledge of undergraduate students has raised concerns in medical schools (Sritharan, 2005; Bagley et al., 2011; Bergman et al., 2008; Prince et al., 2005; Waterston and Stewart, 2005). These shortcomings in anatomical knowledge have also been linked to the increase in medico-legal complaints against surgeons (Ellis, 2002).

In order to maintain the essential undergraduate anatomy curriculum but, at the same time, impart knowledge on new indispensable clinical skills, the incorporation of basic sciences in clinical classes was recommended (Elizondo-Omaña et al., 2010). The implementation of three-dimensional animation design,

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cross-sectional teaching using MRI and CT scans as well as other sophisticated techniques may not only facilitate the teaching of anatomy but also help to incorporate it in the clinical syllabus (Turney, 2007; Shaffer, 2004; Johnson et al., 2012; Schober et al., 2014; Schramek et al., 2013). In gynaecology and obstetrics, endoscopy and ultrasound are routine clinical skills with potentially good teaching capabilities.

Ultrasound plays a central role in medical diagnostics and therapy in primary, secondary and tertiary health care facilities (Levi, 1997). Being safe, easily available, non-invasive, non-radiating, illustrative and easy to perform, it can present anatomical planes and therefore also be an optimal teaching tool. Furthermore, many ultrasound devices are small hand-held units, making them ideal for student teaching purposes (Campbell, 2013; Mulvagh et al., 2014; Alpert et al., 2009). Due to the intimacy of gynaecological examinations, gynaecological ultrasound has received little attention in undergraduate medical education. However, rising numbers of ultrasound-based teaching programs in clinical subjects, including gynaecology, have been reported (Mulvagh et al., 2014; Hamza et al., 2016; Blackstock et al., 2015; Hoppmann et al., 2006, 2008, 2011a, 2011b, 2012, 2014, 2015; Connolly et al., 2015; Dinh et al., 2015; Solomon and Saldana, 2014; Baltarowich et al., 2014; Cawthorn et al., 2014; Cortez et al., 2014; Wagner et al., 2014; Bahner et al., 2014; Mouratev et al., 2013; Knobe et al., 2012; Brown et al., 2012a; Dubosh, 2011; Rao et al., 2008; Fernandez-Frackelton et al., 2007). Using ultrasound, the anatomy of the small pelvis can be well presented, hence connecting the undergraduate anatomy curriculum with obstetrics and gynaecology as a clinical undergraduate subject (Hoppmann et al., 2015; Brown et al., 2012b).

Nowadays laparoscopic operations cover almost the whole spectrum of visceral surgery (Nano, 2012). Using high resolution and even three-dimensional imaging to envisage the female pelvis, viscera and retroperitoneum, laparoscopy also possesses a high potential of teaching properties (Wenzl et al., 1993; Baum et al., 2017; Van Bergen et al., 2000; Wagner et al., 2012). Operators have optimized the use of the technological advances for postgraduate training programs by presenting the steps of complicated operative procedures live in the operation room or using online video streaming (Ponsky and Rothenberg, 2015; Damore et al., 1999; Hiranaka et al., 2017). The idea of incorporating laparoscopy into an anatomy undergraduate teaching program is not new. In a series of projects, surgical laparoscopy on “fresh cadavers” has been incorporated in undergraduate teaching projects and showed a positive teaching effect (Saberski et al., 2015; Glasgow et al., 2006; Fitzpatrick et al., 2001).

To the best of our knowledge, no undergraduate human anatomy teaching program has yet included attendance in a theatre where live surgery on living human beings has been performed or in outpatient clinics where gynaecological ultrasound is performed using current advanced technology as a systematic illustration method for anatomy students (Metheny and Gajewski, 1998). Despite this unprecedented and quick technological advance and the easiness of the presentation of anatomical planes, little has been done to incorporate laparoscopic surgery in undergraduate anatomical teaching programs (Hamza et al., 2016).

Our study aims at presenting the illustrative advantages of gynaecological ultrasonography and gynaecological endoscopy for students enrolled in the anatomy course.

2. Methods

This was a conjoint project between the Department of Obstetrics, Gynaecology and Reproductive Medicine and the Institute of Anatomy, Cell and Developmental Biology of the University of Saarland.

2.1. Preparation of the students

We offered a voluntary course to 25 anatomy students enrolled in the winter term of 2016/2017. The students were participants of the disection course and had finished their lectures and cadaver dissection of the female pelvis to be eligible for the course. After enrolment in the program, the students received a briefing on ultrasound as a diagnostic tool. The sono-anatomy of the female pelvis was explained in 60 min. This was followed by another briefing in which operative laparoscopy was presented in 60 min. The students were then allocated to clinical phase groups who received a one-hour presentation of these clinical skills.

2.2. Assignment of the tutors

The course was held by gynaecologists and obstetricians and the presentation was given by an obstetrics and gynaecology consultant.

The tutors of the ultrasound course were consultants of the ultrasound outpatient clinic of the Department of Obstetrics and Gynaecology. After obtaining board-certification in obstetrics and gynaecology, they sub-specialized in ultrasound according to the guidelines of the German Society of Ultrasound (DEGUM) and Maternofetal Medicine and the German Board of Medicine (Metheny and Gajewski, 1998). They have had at least 8 years of training and experience in treatment and education after their graduation from medical college.

The tutors of the operative course were consultants of the Department of Obstetrics and Gynaecology, who, after board-certification in obstetrics and gynaecology, then sub-specialized in minimal invasive surgery according to the guidelines of the German Society of Gynaecological Endoscopy (AGE, 2017) and Operative Gynaecology and the German Board of Medicine (Saarlandes Äd, 2013). Their training and experience in treatment and education lasted at least 8 years after their graduation from medical college.

2.3. Student group allocation

In the Department of Obstetrics and Gynaecology, the students were divided into two groups (A and B), based on their own choice. Each teaching physician was assigned one anatomy student.

2.4. Clinical exposure phase

In the outpatient clinic group A was presented with ultrasound imaging of the urinary bladder, Douglas pouch, the uterus, endometrial lining and its adnexa of attending patients. Using transabdominal and transvaginal approaches, non-pregnant, early pregnant and puerperal uteri were scanned, showing the mid-sagittal plane and cross sections of the uterus with the endometrium.

Group B attended in the operative theatre, mostly in laparoscopic procedures that involved the uterus, i.e. excluding patients who had had a hysterectomy. In one instance, no laparoscopic surgery was carried out but a vaginal hysterectomy was performed. After the excision, the anatomy of the freshly-excised uterus was explained.

The anatomical knowledge of the students was derived from their anatomy lectures, cadaver dissection and the theoretical part of this course. 13 students chose to attend the laparoscopy session in the operative theatre, while 12 students chose to witness the ultrasound sessions in the outpatient gynaecological clinic. Each student received a log book, where the cases had to be documented

Table 1
The mean (Likert scale) responding with agree (2) or strongly agree In the right column p-values, using chi square and Fischer-Exact tests, to compare the answer on the questionnaire between groups A and B.

	Mean Likert score Group A	Mean Likert score Group B	Mean Likert score both groups	Standard deviation	p-Value
Questions common to both groups ps					
Was the course satisfactory?	1.3	1.2	1.2	0.4	1
Did attending the course make the learning process more enjoyable?	1.5	2.1	1.8	0.8	0.4
Were you able to expand your knowledge in that course?	2.4	3.0	2.7	1.2	0.7
Would you like future courses to take place in the anatomy institute building?	4.3	4.0	4.1	1.2	1
Did the external location of the course make it more interesting?	1.7	2.4	2.0	1.2	0.4
Were the gynaecologists and obstetricians good at explaining anatomy to you?	2.1	1.8	2.0	0.9	1
Would you recommend this course to others?	2.0	2.3	2.1	0.9	0.7
Was there an opportunity to talk to the physicians?	2.3	2.5	2.4	1.4	0.4
Were your questions answered?	1.8	1.8	1.8	1.3	0.7
Was there time to ask questions? And get answers?	2.2	2.0	2.1	1.6	0.7
Were we able to introduce new aspects during that course?	2.1	2.7	2.4	1.3	0.7
Group A					
Did the panoramic view illustrate interesting anatomical structures?	1.6			0.9	
Was there an advantage of laparoscopic surgery over the conventional theoretical anatomical course?	2.5			1.5	
Was there an advantage of laparoscopic surgery over the conventional cadaver dissection?	2.8			1.6	
Were you allowed to take part at the operative table?	3.5			1.9	
Did you experience any problems in dealing with the operative personal?	4.6			1.0	
Group B					
Were you able to scan patients yourself?		3.8		1.8	
Was there an advantage of ultrasound over the conventional theoretical anatomical course?		3.1		1.2	
Was there an advantage of ultrasound over the conventional cadaver dissection?		2.9		1.1	
Did you experience problems in dealing with patients?		5		0.4	
Did you already have ultrasound experience?Did you take part in the sono-by-students initiative of the university?		5		0.8	
Was ultrasound of more advantage than laparoscopy in learning the anatomy of the female pelvis?	2.6	3.0			0.4

for personal documentation. The log books were not evaluated later. They also received a questionnaire, that had to be answered before they left. The questions are shown in Fig. 1 and Table 1.

2.5. Evaluation phase

After the clinical exposure phase, collective interviews were conducted with the students. The aim of the course was discussed with them and the clinical skills which had been presented were again explained. Furthermore, not only different aspects of the female pelvis but the logistics of the course itself were discussed.

	1	2	3	4	5
The clinical skill training helps me to recognize the anatomy of the female pelvis					
I encountered no problems during the clinical skill training					
I have greatly profited from the clinical skill training					
The clinical skill training improved the quality of my medical curriculum					
I am in favour of more clinical skills in gynecology					
I am in favour of more clinical skills in other subjects					
The clinical skill training improved my understanding of human anatomy					
I was provided with sufficient knowledge about the clinical skill					
I was motivated during the clinical skill course					
This introduction to the clinical skill training has motivated me to become a gynaecologist in the future					

Fig. 1. The 1st questionnaire. Respondents rate the question using a number from 1 to 5 as indicated in the figure.

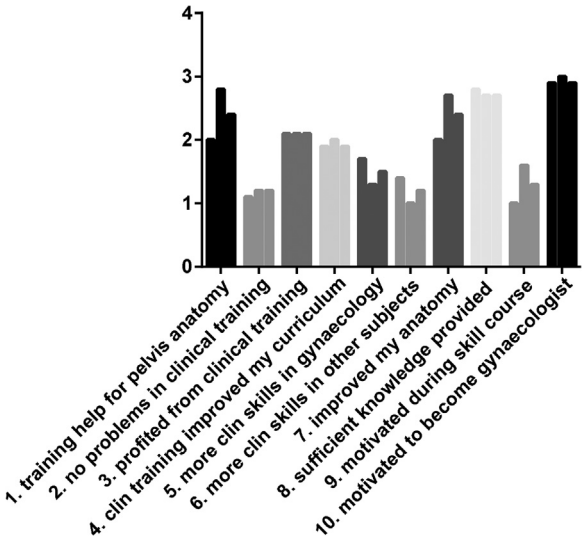

Fig. 2. Presenting the questions of questionnaire 1 with the corresponding mean Likert scores. First column in each question group represents Group A (ultrasound), second column represents Group B (laparoscopy) and third column represents both groups.

The students were questioned on advantages, disadvantages, benefits and weaknesses of the pilot studies. Suggestions for quality improvement were noted. We then asked the students to answer a set of 16 questions involving the quality and content of the course. Eleven questions were common to both groups, while 5 additional questions specifically addressed laparoscopy or ultrasound, respectively, as shown in Fig. 1.

2.6. Statistical analysis

In the questionnaires, we analysed the answer scales as continuous variables. Using SPSS Version 20 (IBM Inc, Armonk, NY) for Mac, we analysed the descriptive data and calculated the mean for a Likert scale assessment.

The Likert scale is an ordered scale used to examine opinions by presenting a spectrum of responses, for which the respondents choose levels such as "strongly agree", "agree", "neutral", "disagree" or "strongly disagree" (Norman, 2010). Questionnaire respondents select one choice best representing their opinion. In the case of our scale, the higher the shift of the mean towards 1, the greater the candidate's agreement or disagreement with the statement/question or vice versa. Our analysis is based on complete cases, with no imputation of missing values. We defined 1 as "strongly agree", 2 as "agree", 3 as "neutral", 4 as "disagree" and 5 "strongly disagree".

In our Likert scale, the more the students agreed with the questions or statements, the more the scale moved to 1 and vice versa as presented in Tables 2 and 3. We also listed the cumulative percentages of the "agree" and "strongly agree" inputs as additional parameters. The Likert scale assessed cumulative percentage and the questionnaire as parameters of student satisfaction with the integration of obstetrical and gynaecological ultrasound and laparoscopy in the undergraduate anatomy teaching program (Fig. 2).

We also compared the answers of the groups A and B with each other using the chi square test. Where 2 cells (50.0%) have expected to count less than the expected Minimum (<5), we used Fischer's Exact Test in some cases.

3. Results

A total of 25 students participated from November 2015 to January 2016. None of the students had any previous experience with ultrasound or laparoscopy or any previous clinical experience. 13 (52%) students chose to take part in the laparoscopic presentation of the female pelvis, while 12 (48%) students chose to take part in the outpatient sonographic program. No student-related data was collected.

3.1. Results of questionnaire 1 (Table 3)

Most of the students reported a positive learning effect: agreeing or strongly agreeing that the training helped them to recognize the anatomy of the female pelvis (Likert score 2.4 (72.6%)), that they generally profited from the clinical skill training (Likert score 2.1 (68.8%)). Half of the students reported that the course had improved their understanding of human anatomy (Likert score 2.4 (53.3%)) and that they had received sufficient knowledge about the clinical skill they had been assigned to (Likert score 2.4 (53.3%)). Approx. one third of the students felt motivated to consider obstetrics and gynaecology as a future career option (Likert score 2.9 (31.3%)).

Despite primary concerns about dealing with patients or operating room personnel (OR-personnel), none of the students reported having had any difficulties (Likert score 1.2 (100%)). None of the patients or OR-personnel rejected the presence of an anatomy student for teaching purposes.

All the students reported being motivated throughout the whole course (Likert score 1.3 (100%)). If the same course was to be offered again, most of the students would participate again (Likert score 1.5 (87.5%)). Most of the students wished to be offered similar courses in other basic science subjects (Likert score 1.2 (93.8%)). According to most of the students, this clinical skill-training program improved the quality of their curriculum (Likert score 1.9 (75%)). The satisfaction, knowledge-gain and personal enthusiasm scale did not differ among group A and B.

3.2. Results of questionnaire 2 (Table 1)

All the students (100%, Likert score 1.24) agreed that a link between anatomy as a subject of basic science and gynaecology as a clinical subject was a good concept. The integration of clinical gynaecology into the anatomy course made the course more exciting for 76% (Likert score 1.8) of the students (Table 1).

Almost half of the students (48–57%, Likert score 2.4–2.7) reported that the attendance of this course had increased their anatomical knowledge.

Many students welcomed the move to another building to witness the clinical illustration as helpful towards a better understanding of the subject in hand (76%–92%, Likert score 2.0). Most of the students reported that their questions had been addressed sufficiently and that they had had time to engage in further discussions with their tutors (60–80%, Likert score 1.8–2.1).

Despite the students' concern at the outset of the project, neither those dealing with patients in the ultrasound group (0%), nor those dealing with the operation setting and personnel (8%) experienced a major problem. Any problems incurred with the personnel were due to violation of hygienic standards or because the way was blocked in the operation room.

73% (Likert score 1.6) found the panoramic view offered by laparoscopy very illustrative of the anatomical relationships of the female pelvis. 39% of the students (Likert score 3.5) scrubbed and assisted, while 25% students (Likert score 3.8) were able to scan patients themselves under the guidance of their tutors. There was a statistical significant difference in the Likert score between those

who scanned/scrubbed themselves and those who only observed ($p > 0.05$).

In the laparoscopy group, more than half of the students considered that laparoscopy offered more advantages than conventional methods in teaching anatomy (62%, Likert score 2.5). 42% (Likert score 3.1) of the students taking part in the ultrasound course reported a similar effect. There was no statistical difference between the two groups (Table 1).

In the ultrasound group, half of the students were of the opinion that sonographic presentations provided advantages in both teaching and understanding anatomy in comparison to cadaver dissection (50%, Likert score 2.9). 39% (Likert score 3.5) of the students taking part in the laparoscopy course reported a similar effect. There was no statistical difference between the two groups (Table 1).

The evaluation also included a free text section for suggestions at the end of the questionnaire. The students reported a coordination problem between the operations and their 1 h blocks, resulting in waiting times or even missing operations. Many students expressed their wish that more opportunities to work with ultrasound and endoscopy be offered in other subjects during the course of their studies.

4. Discussion

Our main objectives in this teaching program were to introduce clinical skills in earlier stages of the medical studies and to eliminate the disjunction between basic and clinical sciences, thus improving the quality of medical studies. Similar approaches using ultrasound imaging were published earlier from a workgroup in the medical school of the University of South Carolina (Hoppmann et al., 2015, 2014, 2012, 2011a, 2011b, 2008).

Being a pilot study, the participation was voluntary which is a weakness of the study. An additional weakness is the low number of participating students. Given the nature of the teaching material (operations on living patients), it was not possible for the anatomy tutor to teach the respective clinical skill. It can be discussed if students in the preclinical phase should practice more transvaginal ultrasound by themselves. The Pros are experience and learning this technique, the Cons are confidence of the patients to the investigator, reliability of results and time slots. The tutors not knowing their fellow tutors and also the tutors not knowing their students, caused a mild dissociation of knowledge. This could be solved by teaching the anatomy tutors how to perform ultrasound. With regard to laparoscopy, the anatomy tutors could receive an advanced course on gynaecological endoscopy. The operational procedure could then be explained by the anatomy tutors themselves via video streaming. This has the advantage that they are fully aware of the knowledge level of their students. The effect of this method is yet to be examined.

Furthermore, we did not achieve the improvement of knowledge we had expected. As presented in Table 1, only 48% of the students reported an expansion of their anatomical knowledge. This could be explained by the short and compressed schedule in the primary design of the project. Each student could attend in the operation room or outpatient clinic for only one hour, which is equivalent to a teaching unit. The coordination between the commencement of an operation and the attendance of the student proved difficult due to the independent planning of the operation schedule. In many instances, patients in the outpatient clinic required longer consultation times, which reduced the number of patients a student could see. These limitations should be taken into consideration in the planning of future projects.

The assessment of the learning effect is based solely on the students' opinions. Contrary to a previous study, we did not conduct a post-test in order to assess the students' knowledge (Hamza et al., 2016). At the beginning of the project we had planned to compare the exam results of students enrolled in our teaching project with those of students who had not attended this course. Unfortunately, it was not possible to reassess the results. In future, we plan to issue a separate set of questions before the course, in order to be able to objectively assess the knowledge level of the students.

Our study reflected a positive attitude among the anatomy students towards the incorporation of a clinical subject into their anatomy course. This is shown by the favourable mean in the Likert score in both questionnaires. This is in line with a recent study by our work group (Hamza et al., 2016), in which clinical students were more involved in practising ultrasound as a clinical skill. This was also confirmed for ultrasound in similar studies (Cawthorn et al., 2014; Knobe et al., 2012; Hofer et al., 2000).

The commitment shown by the physicians in teaching normal anatomy to students despite their heavy daily workload, received a positive response, as documented by 60–80% of the questionnaire responders. One of the consultants even went to the anatomy department on a separate day to explain to a group of students what they had seen in the operating theatre. This input is also documented in the second questionnaire in questions 8 to 10 (Likert score 1.8–2.4, 60–80%). These reciprocal interactions were welcomed by the teaching boards of both institutions. Further steps are being planned to promote increased interaction between the departments and improve undergraduate curricula.

The impact of financial issues in introducing a new teaching program was considered. The consultation and examination time every patient received could not be compromised. The anatomy course's tight schedule also put limitations on the time available. But nowadays an early understanding of how to use ultrasound and laparoscopy techniques is equivalent to the past role of stethoscope and scalpel. This central role of ultrasound and laparoscopy in medical practice and the enhanced presentation of the human anatomy they enable, justify more complicated and time-consuming teaching programs. This requires both additional time and greater funding. The fact that the reduction in the teaching time of basic sciences has affected the quality of medical care (Johnson et al., 2012), requires, in our opinion, a fundamental change in teaching philosophy. In future, we plan to train student tutors and to increasingly implement online teaching programs in order to provide more effective teaching programs with the current limited resources (Albrecht et al., 2013). The combination of student tutors and online teaching methods in medical teaching programs has been proven to be effective (Celebi et al., 2012).

Notwithstanding our primary concerns about the difficulty of organising the course in two separate departments, only 8% of the students think that this course would be better if organized in their original department (Table 1). 76% of the students (Likert score 2.0) were of the opinion that attending a course elsewhere made it even more interesting. In the additional comments section many of the students welcomed the change in location and atmosphere as it gave them a new angle on the same topic. To our knowledge, this is the first project that incorporates current imaging technologies of operative laparoscopies on living patients in a basic science undergraduate curriculum. We are of the opinion that the integration of ultrasound with laparoscopy in the undergraduate medical curricula offers great potential. This especially applies to basic sciences, obstetrics and gynaecology, but also to other disciplines.

5. Conclusion

Human anatomy is one of the cornerstones of basic sciences in medicine. The introduction of clinical skills, i.e. ultrasound and laparoscopy, as an added explanatory method is a promis-

ing approach to foster the understanding and quality of human anatomy and link it to future clinical subjects. In addition to the learning effect, the combination of basic sciences with clinical disciplines can also indirectly increase the hours of teaching in human anatomy. It further enables the introduction of new clinical skills in the early stages of training of our future physicians. It is vital to foster an understanding of basic sciences in order to improve medical standards, thus improving the quality of health care and reducing medico-legal litigation, while, at the same time, providing students with the opportunity of learning up-to-date clinical skills.

Author contributions

AH: wrote the manuscript, JR: reviewed and edited, GMS: reviewed and edited, EFS: reviewed and edited, ZT: reviewed and edited, IJB: reviewed and edited, RS: reviewed and edited, RJ: reviewed and edited, GKC: reviewed and edited, TT: reviewed and edited, SM: reviewed and edited

Compliance with ethical standards

The manuscript is in compliance with the ethical standards of the declaration of Helsinki and the code of ethics of ElSevier.

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Ethical approval

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