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Research article

A prospective case-control study on online teaching of ultrasonography skills to medical students during COVID-19 pandemic

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ABSTRACT

Introduction: A new Online interactive Ultrasound Teaching (OUT) was developed in our institution in March 2021 during COVID-19 outbreak.

Methods: This is a case control study on 65 final year medical students to compare OUT with conventional face-to-face ultrasound tutorials. There were 31 female and 34 male students. Median age was 23 years old (Range 21–30). Students were randomly assigned into two different teaching groups. Competency in conducting ultrasonic exam was assessed by Objective Structured Assessment of Ultrasound Skills (OSAUS).

Results: 32 students were randomized into the control group (face to face teaching) while 33 students were randomized into the case group (OUT). Baseline demographic characteristics were comparable between the two groups ($p > 0.05$).

The median score of the blinded OSAUS assessment was 5.5 (Range 3–7). There were 4 (6.2%) students who failed in the assessment (scored <4 out of 7), and 10 (15.4%) students scored full marks in the assessment.

The medians scores were 5.5 (Range 3–7), and 6 (Range 3–7) ($p = 0.8057$) in the control and case groups respectively. 6 (18.8%) students in the control group scored full mark, comparing to 4 (12.1%) students in the case group ($p = 0.5105$). 2 students from each group failed the assessment ($p = 1$).

Conclusion: Ultrasonographic skills performance was comparable between students who were taught by OUT and conventional face-to-face tutorial.

1. Introduction

Global pandemic coronavirus disease 2019 (COVID-19) has affected more than 210 countries after the initial outbreak in Wuhan, China in December 2019 [1]. Nearly 300 cases were reported in January 2022. Most countries have implemented strict social distancing measures aiming to slow down the spread, including closure of schools from primary to tertiary education [2]. COVID-19 outbreak occurred in Hong Kong in January 2020 after the first imported case from mainland China. Hong Kong SAR government responded with implementing strict social distancing measures. Schools were closed to prevent unnecessary crowding of students in the schools or campuses. Medical education in Hong Kong was also severely affected. In order to prevent hospital acquired infection, medical students were not allowed to participate any clinical activity in the hospital and has to attend classes at home [3].

Medical students in Hong Kong have to undergo three years of preclinical teaching and another three years of clinical teachings (Curriculum differs slightly between the two medical schools in Hong Kong). Upon graduation, medical students in Hong Kong are given provisional registration by the Medical Council for one-year internship training before full medical registration is allowed. Basic surgical sonographic skills are normally taught face-to-face by a general surgeon (MC) in the final year of medical curriculum in our institution. The teaching was conducted in the form of an interactive tutorial. Students are expected to acquire sonographic skills on detecting common surgical condition. The syllabus of the surgical sonographic teaching is listed in Table 1. Final year medical students are divided into 7 groups with approximately 30–33 students per group.

This face-to-face interactive tutorial on surgical ultrasonography was introduced to the final year medical curriculum in 2017. Students were given a short lecture on basic operation of the ultrasound machine (including machine set-up, image acquisition, image interpretation), followed by a live demonstration of ultrasonography and hands-on practice between the students (mainly Head and Neck, Thyroid and Abdomen) (Figure 1). Five ultrasound machines were available for sharing between 30 – 33 students. Duration of the face-to-face interactive

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Table 1. Syllabus of final year undergraduate surgical ultrasound teaching.

	Identification of normal anatomy	Identification of common conditions
Head and neck	Cervical lymph nodes Thyroid Carotid artery Internal and external jugular veins	Cervical lymphadenopathy Thyroid nodule Carotid body tumour (optional) Parotid tumor (optional)
Breast	Breast Axilla	Benign breast cysts/fibroadenoma Malignant breast lesions Axillary lymphadenopathy
Hepatobiliary system	Gallbladder Liver Common bile duct and biliary system (optional) Hepatic artery and portal venous system (optional)	Gallstone Cholecystitis Liver mass Liver abscess Ascites Dilated common bile duct (optional)
Urology	Kidney Urinary bladder	Hydronephrosis Renal mass Urinary bladder tumor (optional)
Vascular	Abdominal aorta	Abdominal aortic aneurysm

tutorial was 180 minutes. Students were allowed to book the ultrasound facilities on their own after the classes for self-practice.

Due to COVID-19 pandemic in Hong Kong, all clinical and face-to-face teaching were suspended. Lectures and talks were delivered online using teleconferencing program Zoom (Zoom Video Communications, Inc. San Jose, CA, USA), operating theatre attachments were replaced by online video archives, basic surgical skills training was replaced by online demonstration [4, 5]. Like other teaching activities, interactive tutorial on surgical ultrasonography was also delivered by a novel online method – Online Ultrasonography Teaching (OUT).

2. Methods

This is a prospective case control on student's performance between those who were taught by OUT (Case) to those who received conventional face to face teaching (Control). Institutional approval was obtained from Center for Education and Training (Surgery), University of Hong Kong. Informed consents were obtained from all medical students.

2.1. Subjects

The study was conducted in March 2021. Face-to-face teaching was allowed by the Government in March 2021 as the number of COVID-19 cases has decreased in Hong Kong. Two consecutive groups of final year medical students were recruited for study, informed consents were taken. Students were randomly assigned to OUT or conventional face-to-face teaching. Final year medical students were recruited for the study as surgical ultrasound curriculum was normally taught in the final year in pre-COVID era.

The case group received 180 minutes of OUT. The control group received 180 minutes of face-to-face teaching by the same tutor MC. Both groups were taught by identical teaching content with standardized syllabus.

2.2. Control group (conventional face to face teaching)

The face-to-face interactive tutorial started with a 30-minute lecture on basic principles on ultrasonography, followed by live demonstration of performing ultrasonography on head and neck, thyroid, and abdomen. Students were then allowed to practice ultrasound among themselves.

2.3. Case group (OUT)

OUT started with a 30-minute online lecture on basic principles of ultrasonography. Like conventional face-to-face teaching, the teaching session was followed by live demonstration of ultrasonography. However, the demonstration was broadcasted live using two cameras (The first camera focuses on the keyboard of the ultrasound, the second camera focuses on the instructor's hands for probe placement). In addition, the ultrasound machine was connected to the laptop which screen was shared to the audience using Zoom™. Camera two was placed behind the instructor to avoid mirror image on the instructor's hand movements. The cameras were operated by a dedicated cameraman. Ultrasound skills were demonstrated on a surrogate patient. Please refer to Figure 1 for the setup of OUT.

Like conventional teaching, students were allowed to interact with the instructor throughout the online session. Students will be able to view three images at the same time from their own computers (Screen one: Ultrasound image; Screen two: Tutor's hand and probe placement; Screen three: Overview on ultrasound machine – knob and button manipulation) (Figure 2).

Students were allowed to book time slots at the clinical skills center for self-practice of ultrasound among the peers after the session.

32 students were randomized into the control group (face to face teaching) while 33 students were randomized into the case group (OUT). Baseline demographic characteristics were comparable between the two groups ($p > 0.05$). The median age of the control group was 23 (Range 21–26), where that of the case group was 22 (Range 21–30). 3 (9.4%) students in the control group were post-graduate students, where 4

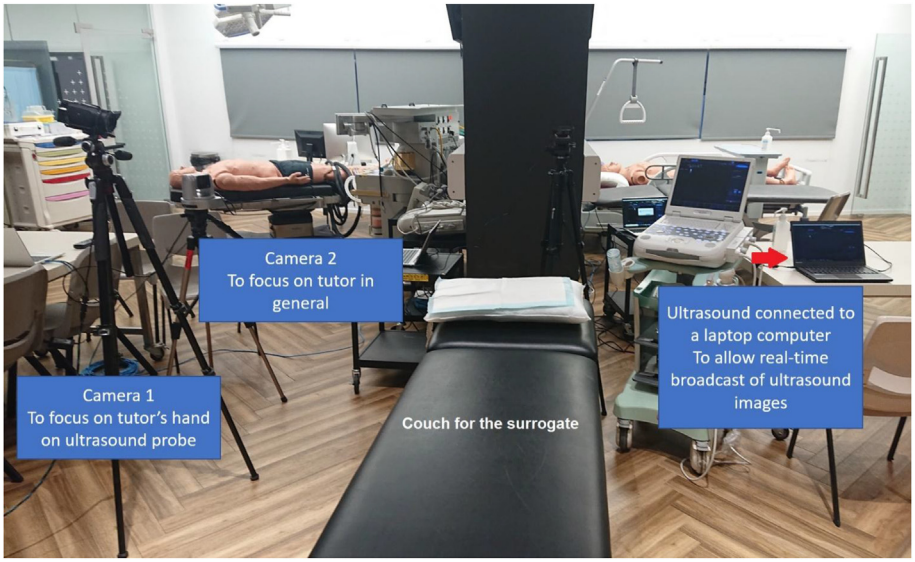

Figure 1. Setup of the online ultrasound teaching (OUT) session.

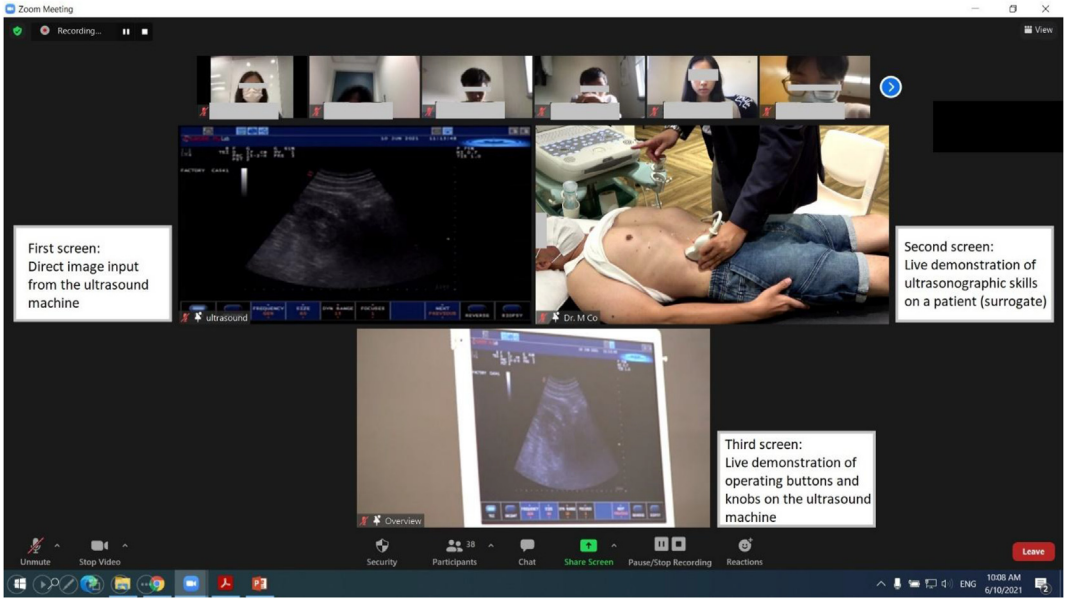

Figure 2. Three images shown simultaneously on students' computer screen.

Table 2. Baseline demographic data between the two groups.

Demographic	Control (Face-to-face teaching) N = 32	Case (Online ultrasound teaching) N = 33	P- value
Median age	23 (Range 21–26)	22 (Range 21–30)	0.7642
Post-graduate student	3 (9.4%)	4 (12.1%)	1.0000
Previous distinction in exam	2 (6.3%)	3 (9.1%)	1.0000
Previous failure in exam	3 (9.4%)	3 (9.1%)	1.0000

(12.1%) students in the case group was post-graduate student. 2 (6.3%) students in the control group have been awarded distinction merit in previous examinations, comparing to 3 (9.1%) students in the case group. 3 (9.4%) students in the control group have failed in one or more medical examinations in the past, comparing to 3 (9.1%) students in the case group. Table 2 summarizes the baseline demographic data of the two groups.

2.4. Assessment

All students were assessed for their ultrasonographic skills and knowledge by a blinded assessment using Objective Structured Assessment of Ultrasound Skills (OSAUS), which allows independent and unbiased assessment on seven aspects of ultrasonographic skills and knowledge of the candidate (1. Indication, 2. Equipment, 3. Image optimization, 4. Systematic examination, 5. Image interpretation, 6. Image documentation, 7. Management). Each aspect of OSAUS scoring system carries 1 mark (i.e. Students will be given 1 mark if he/she performed satisfactorily in that item, 0 mark will be given for those who did not perform satisfactorily). The maximal score of the assessment was 7, passing score was defined as 4.

2.5. Primary endpoints

An independent assessor was blinded for which teaching method students had received. Standardized OSAUS criteria were used for unbiased assessment of individual students.

2.6. Statistical analysis

Demographic characteristics and scores of the clinical competency assessment of students between the two groups were compared by Fishers exact test, chi-square test or student's T test where appropriate. Non-parametric test such as Chi-square test/Fishers exact test was used due to the relatively small sample size and like that the dataset is not in normal distribution.

3. Results

A total of 65 medical students were recruited into the study, median age was 23 years old (Range 21–30 years old). There were 31 female and

Table 3. Summary of students' score by the blinded assessment.

	Control (Face-to-face teaching) N = 32	Case (Online ultrasound teaching) N = 33	p-value
Median overall score (Range)	5.5 (3–7)	6 (3–7)	0.8057
Distinction (100% overall score)	6 (18.8%)	4 (12.1%)	0.5105
Failure (<50% overall score)	2 (6.3%)	2 (6.1%)	1.0000
Passed item 1 (Indication)	32 (100%)	33 (100%)	1.0000
Passed item 2 (Equipment)	32 (100%)	33 (100%)	1.0000
Passed item 3 (Image optimization)	26 (81.3%)	27 (81.8%)	1.0000
Passed item 4 (Systematic examination)	25 (78.1%)	26 (78.8%)	1.0000
Passed item 5 (Image interpretation)	21 (65.6%)	20 (60.6%)	1.0000
Passed item 6 (Image documentation)	20 (62.5%)	20 (60.6%)	1.0000
Passed item 7 (Management)	22 (68.8%)	23 (69.7%)	1.0000

Figure 3. Hybrid method for surgical ultrasound teaching.

34 male students. All students were in their final year of undergraduate medical curriculum.

All students were assessed by a blinded assessor using OSAUS assessment protocol, seven areas were objectively assessed, namely 1. Indication, 2. Equipment, 3. Image optimization, 4. Systematic examination, 5. Image interpretation, 6. Image documentation and 7. Management. The median score was 5.5 out of 7 (Range 3–7). There were 4 (6.2%) students who failed in the assessment (scored <4 out of 7), and 10 (15.4%) students scored full marks in the assessment.

There was no statistically significant difference in terms of the median total score between the control and case groups. The medians scores for control and case groups were 5.5 out of 7 (Range 3–7), and 6 out of 7(Range 3–7) respectively ($p = 0.8057$). 6 (18.8%) students in the control group scored full mark in the assessment, while 4 (12.1%) students in the case group scored full mark ($p = 0.5105$). 2 students from each group failed in the assessment ($p = 1$).

Subgroup analysis of students' performance on individual item of the OSAUS assessment did not reveal significant statistical difference between the two groups. All students were able to perform satisfactorily for items 1 and 2 (Indication and equipment) of the OSAUS. Students' performance on item number 5 and 6 (Image identification and documentation) were lower in the case group when compared to the control group, although significant statistic difference between the two group cannot be demonstrated in this subgroup analysis (Table 3).

There were no reported difficulties on program/hardware installation by the students for the OUT session.

4. Discussion

COVID-19 is a highly infectious disease, in the absence of promising treatment and vaccination program, the best policy to contain the COVID-19 transmission by implementing strict social distancing and lockdown measurements [6].

Medical education in many affected areas has switched the conventional physical teaching format to online classes. However, unlike primary or secondary education, delayed graduation from medical schools can result in disastrous outcomes during COVID-19 pandemic [3, 7, 8, 9]. While lectures and talks can be easily delivered online; training of ultrasonographic skills, which requires high level of teacher-student interaction, may not be easily demonstrated by pre-recorded videos.

Benefited from our previous experience in delivering interactive classes on surgical skills by online method since March 2020 [4,5], our department has also introduced online ultrasound teaching to final year medical students since March 2021.

Here we described a novel teaching method for undergraduate ultrasound training by using a commercially available software program. This online teaching of ultrasonographic skills has overcome two important obstacles to clinical skills learning during the COVID-19 pandemic – Lack of face-to-face interaction as well as real-time feedback during the learning. The alternative of providing a pre-recorded video demonstrating the same skills would not be able to achieve the same effect. OUT was delivered with real-time skills demonstration by two cameras, camera one focuses on overall picture, while the second camera focuses the tutor's hands. In addition, image on the ultrasound machine was broadcasted live via Zoom™ by connecting the ultrasound machine to tutor's laptop computer (Figure 1). Camera angle and power of magnification of tutor's hands could be adjusted at any time by the cameraman. Students were allowed to make comments or ask questions throughout the OUT session. Another important advantage of OUT is clarity of skills demonstration. Unlike face-to-face tutorials where students sitting at the back may have limited views, OUT allows demonstration of ultrasonographic skills to all students equally.

We recognize the inherent weaknesses in this study, including the relatively small sample size of 65 students. We only recruited two consecutive rotations of medical students into this study, hoping that by performing a quicker analysis and validation of OUT, this novel ultrasound teaching method can be promptly evaluated and introduced during COVID-19 pandemic. Another limitation of OUT is that students taught by OUT still have to go back to the skills center in the campus for self-practice, although overcrowding can be avoided as the time-slots for self-practice were flexible.

Nevertheless, this is the first prospective case-control study on this novel ultrasound teaching method. Blinded assessment using OSAUS also allowed unbiased and standardized evaluation of students' performance. We believe results from this study provide important evidence to support the use of OUT in undergraduate medical curriculum during COVID-19 pandemic.

Setup for OUT is inexpensive, it does not require special computer program or professional broadcasting equipment. Two cameras, one ultrasound machine and one laptop installed with telecommunication software (e.g. Zoom™) are all that is needed for OUT.

Adaptations of medical education during COVID-19 pandemic has allowed us to revisit distance learning. Online teaching is flexible, it will be valuable and complementary to conventional physical method even after COVID-19 pandemic. At the time of writing in December 2021, physical (face-to-face) teaching was already resumed in Hong Kong. With the lessons learnt from OUT, the author has started teaching surgical ultrasound to final year medical students with hybrid method. Students were invited to attend surgical ultrasound classes physically, but with the skills demonstration broadcasted live using the same setup from OUT (Figure 3). This hybrid method allows face-to-face interaction while retaining the advantage from OUT where close-up views of tutors' demonstration will be projected to the screen and zoomed. Students will be able to watch skills demonstration both live and from their own tablet devices/laptops.

5. Conclusion

Ultrasonographic skills performance was comparable between students who were taught by OUT and conventional face-to-face tutorial.

Declarations

Author contribution statement

Michael Co: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Kent-Man Chu: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare the following conflict of interests: Michael Co served as the unpaid Guest Editor of the special issue "Medical Education during the COVID-19 pandemic – Lessons learnt and the way forward" in Heliyon. The peer review process of this article was handled by an unaffiliated Associate Editor at Heliyon.

Additional information

No additional information is available for this paper.

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