Clinical pathology clerkships contribute greatly to pathology education and residents recruitment: a randomized and prospective study from China

Siyuan Gan[1], Rujia Li[1], Yanping Ha[1], Zhenning Zou[1], Ruifang Ye[1], Wei Jie[1], Xiaoqing Di[2], Wenhua Hu[2], Yanqin Sun[1]

Corresponding author: Dr Yanqin Sun 215193703@qq.com
Institution: 1. Department of Pathology, Guangdong Medical University, 2. Department of Pathology, the Affiliated Hospital of Guangdong Medical University
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Abstract

Background
The traditional teaching mode (lecture-based learning and experiment course) of pathology lacks adequate specimens with typical pathological changes and exposure to clinical pathology. This deficiency has greatly dampened students’ interest in learning pathology and weakened the effect of teaching pathology. Even worse, it impedes the recruitment of pathology resident.

Objective
We prospectively compared the impact of three teaching modes (experiment course, clinical pathology clerkship course, clinical pathology clerkship course and experiment course) on academic results and student perceptions to assess the role of clinical pathology clerkships in pathology education.

Design
One hundred eighty students were randomly allocated into the experiment course (EC), clinical pathology clerkship course (CPCC) group, or CPCC and EC group. Academic results were assessed through a review of written examinations, pathological specimen observation tests, and student performance scores. Two questionnaires were used to evaluate student perceptions.

Results
Compared to the EC group, all CPCC participants exhibited superior performance in written examinations, pathological specimen observation tests, and overall performance (P< 0.05 or < 0.01). However, the dual CPCC and EC group had better results than the CPCC group (P< 0.05 or < 0.01). Compared to EC, CPCC was more effective in developing students’ interest in learning pathology and their ability to observe specimens, as well as facilitating
students’ initiative to choose pathology as a career choice (P< 0.05 or < 0.01).

Conclusions
CPCCs are helpful in improving students’ pathology learning. However, the teaching mode (CPCC and EC combined) provides greater benefits for students’ pathology learning. CPCC may contribute to improving pathology resident recruitment.

Keywords: clinical pathology clerkship; pathology education; experiment course; pathology recruitment; resident choice

Introduction
Specific diagnoses based on morphology are considered to be a core skill of pathology (Rosai, 2001; Moran and Suster, 2007). In addition, morphological observation of specimens is highly significant to the learning and teaching of pathology curricula (Domizio, 2006). However, at present, many challenges exist in teaching pathology in medical colleges worldwide. Autopsy demonstrations, which have been popular with generations of medical students, are becoming irregular and less well attended, reducing student exposure to macroscopic pathology and clinicopathological correlation. Funds used to maintain pathology museums that possess many specimens are in short supply (Domizio, 2006). Hence, gross specimens (GS) and microscopic slides (MS) used for teaching in experiment courses (ECs) are very old, and updating them is difficult, making pathological changes in specimens atypical and unclear. In addition, the number of available specimens is also insufficient. These problems lead to difficulty in student observation and learning pathological changes in specimens in ECs.

At the same time, traditional pathology teaching methods in many medical colleges have always adopted traditional lecture-based learning (LBL) (K. Kumar, Indurkhya and Nguyen, 2001; Herrmann et al., 2015), which lacks clinical exposure. It has been identified as an archaic mode of teaching, and have realized this and pressed for change (Herrmann et al., 2015). The increased difficulty in observing and learning pathological changes, the absence of clinical teaching, and so on, greatly dampen students’ interest and initiative in learning, and the teaching and learning effect of pathology, a highly practical subject, will suffer. Meanwhile, learning morphology is important for the overall understanding of pathology. Lack of this modality may lead to negative impacts on students' interest and recruitment of pathology resident long term (K. Kumar, Indurkhya and Nguyen, 2001).

Pathology has been frequently identified as an unpopular career choice for medical students in many countries. There have been predictions that this unpopularity would lead to a shortage of pathologist, which would in turn contribute to reduced laboratory quality and patient care (Harris, Gavel and Young, 2005; Turner, Lambert and Goldacre, 2006; Jason C Ford, 2010; Hung and Jarvis, 2011). Reasons presented by previous studies for this trend include difficulties in attracting prospective pathology residents and the relative "invisibility" of pathology, as well as the fact that medical students lacking sufficient preclinical exposure to pathology are unlikely to select pathology clerkships or residencies (Jason C Ford, 2010; Brooks et al., 2016). Since the practitioners seem to work behind the scenes and engaged in unknown activities that miraculously lead to diagnostic reports, pathology is regarded as a mystery by many medical students. In this environment, simple promotion of traditional pathology EC electives seems unlikely to succeed in improving student interest and recruitment.

Studies have also demonstrated that most of second-year medical students have already formed definite specialty preferences. Meanwhile, the traditional the second-year pathology course contribute too little to promote students’ perceptions of pathology. Since pathology is considered to be a viable career option, positive early exposure is
necessary (Holland and Bosch, 2006). Previous studies have suggested improved clerkship experiences in pathology to raise pathology's profile and to improve pathology resident recruitment (Raphael and Lingard, 2005; Holland and Bosch, 2006). Previous study has demonstrated that integrating pathology into the clinical curriculum will enhance student interest in pathology and choice of pathology as a career. Meanwhile the curricular changes will contribute a lot to improve student pathology recruitment (Chu, Mitchell and Mata, 2016).

Previous studies also demonstrate that student exposure to clinical pathology has a positive impact on choice of pathology (Es et al., 2015; Brooks et al., 2016; Chu, Mitchell and Mata, 2016). The goal of our study was to expose students to pathology such that it was no longer clinically invisible. We also hope that through clinical pathology clerkship courses (CPCCs), the work flow, importance, and goals of pathology will be more effectively revealed to students, providing a set of defined milestones for medical students.

Practical trials in medical education may contribute to bridge the gap between education theory and practice and aid decision makers in making evidence based choices and priorities (Tolsgaard, Kulasegaram and Ringsted, 2017). We conduct a CPCCs trial with rigorous design and method. Through CPCCs, we can utilize specimens with typical and clear pathological changes to find novel methods to solve the problems in traditional teaching modes of pathology and the crisis in recruitment of pathology resident. We hypothesized that CPCCs would be an effective stimulus in improving student interest in learning, observation ability, and academic results in pathology. Through facilitating exposure to the field of clinical pathology, pathology may be a more attractive career choice for students.

**Methods**

One hundred eighty second-year undergraduate students in six classes of Guangdong Medical University were enrolled in this study, with 30 students in each class. Results for written examinations and EC examinations of anatomy, histology, and embryology in the six classes were statistically analysed, and there were no differences among any of the classes (Table 1, P>0.05). It is generally known that learning and teaching of pathology should be based on anatomy, histology, and embryology curriculum. Therefore, with these statistical results, we made a preliminary conclusion that students of the six classes possessed the same level of theoretical knowledge and practical ability for pathology learning.

**Table 1: Comparison of the academic results of anatomy, histology and embryology in six classes (n=30/class) (mean ± SD).**

<table>
<thead>
<tr>
<th>Class</th>
<th>Written examination</th>
<th>Experiment test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>69.9±8.7</td>
<td>80.3±9.7</td>
</tr>
<tr>
<td>2</td>
<td>69.3±7.3</td>
<td>81.8±10.2</td>
</tr>
<tr>
<td>3</td>
<td>73.3±8.4</td>
<td>82.6±10.8</td>
</tr>
<tr>
<td>4</td>
<td>70.9±6.0</td>
<td>85.1±7.7</td>
</tr>
<tr>
<td>5</td>
<td>72.6±6.5</td>
<td>82.3±9.8</td>
</tr>
<tr>
<td>6</td>
<td>73.2±8.3</td>
<td>81.9±9.7</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.177</td>
<td>0.565</td>
</tr>
<tr>
<td>Histology &amp; Embryology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>69.9±7.5</td>
<td>78.3±11.9</td>
</tr>
<tr>
<td>2</td>
<td>71.3±7.9</td>
<td>85.7±10.5</td>
</tr>
<tr>
<td>3</td>
<td>69.7±8.8</td>
<td>85.3±10.9</td>
</tr>
</tbody>
</table>
The study was obtained verbal consent from study participants. Participation was voluntary. Participants were informed about the aim and methods of the study and were explicitly asked to provide permission for the study. This informed consent was required before we could start the study. Participants could stop their participation in the study at any time. The data for this study were processed anonymously and data of individual respondents were not traceable in the presented results. The study was approved by the Institutional Ethical Review Board of the affiliated hospital of Guangdong Medical University. Since the study was an educational activity and the participants were not allowed to conduct any practical work or operations that might affect the pathology diagnose in the CPCCs.

Using a randomly numbered table, the classes were randomly assigned into three groups: the EC group, CPCC group, or EC and CPCC group, each consisting of two classes with a total of 60 students. In addition, all groups received traditional LBL with the same teacher. Groups with CPCCs were divided into eight subgroups, each consisting of 15 students. The groups with traditional ECs received the course through observing GS and utilizing microscopes to observe MS. Both ECs and CPCCs lasted 12 weeks, and there were no differences in instruction time between the courses.

All teaching was performed by the same faculty members.

Clinical pathology clerkship course
Each subgroup participated in a weekly CPCC based on the CPCC teaching schedule (Table 2) in the Pathological Diagnosis and Research Centre of the affiliated hospital of Guangdong Medical University. The specific scheme was as follows:

1. In the CPCC, starting from receiving and numbering of gross specimens, we gradually introduced and demonstrated fixation of the GS, pathology dissection and gross examination of the specimen, the wax block, microtomy and paraffin section preparation, and all processes and significant matters in pathology diagnosis. Through this teaching, students could understand the process and quality control standards of pathology work, as well as the importance of pathological diagnosis and learning pathology.

2. In the demonstration of pathology dissections and gross examination of specimens removed from typical clinical cases, we selected those GSs with typical pathological changes and guided the students in observing the typical pathological features of GS while considering the corresponding links between clinicopathological and clinical data.

3. To better integrate pathological changes observed under the microscope with pathological changes in the GS, in the observation of MS from typical clinical cases, we selected MS prepared from the GS demonstrated in CPCC the week prior. We also carefully selected specimens with pathological changes corresponding to the LBL teaching schedule. A multi-viewing microscopes and digital microscope slide scanning system were applied for observation and teaching.

4. By observing specimens and understanding pathological changes therein, we encouraged and guided students to have discussions with each other before making corresponding pathological diagnoses and providing descriptions of their diagnostic basis.

5. In the clinicopathological discussion, through the hospital information management system, clinical history, physical examination, laboratory, and imaging examination of the cases were introduced, and videos of the examination of gross specimens were played to review pathological changes. We also applied a multi-viewing
microscope and digital microscope slide scanning system for observing and teaching MS. Then, students were organized and guided to discuss the clinical data and pathological changes and to make corresponding pathological and clinical diagnoses, as well as to explain the diagnostic basis. Finally, the instructor provided the correct diagnosis and a comment on the students’ answers.

Table 2: Clinical pathology clerkship schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Daily Arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4th</td>
</tr>
<tr>
<td>2</td>
<td>5th</td>
</tr>
<tr>
<td>3</td>
<td>6th</td>
</tr>
<tr>
<td>4</td>
<td>7th, Same with the 5th week.</td>
</tr>
<tr>
<td>5</td>
<td>8th</td>
</tr>
<tr>
<td>6</td>
<td>9th</td>
</tr>
<tr>
<td>7</td>
<td>10th</td>
</tr>
<tr>
<td>8</td>
<td>11th</td>
</tr>
<tr>
<td>9</td>
<td>12th</td>
</tr>
<tr>
<td>10</td>
<td>13th</td>
</tr>
<tr>
<td>11</td>
<td>14th</td>
</tr>
<tr>
<td>12</td>
<td>15th</td>
</tr>
</tbody>
</table>

### Experimental course

In the EC, students mainly used the microscope to observe pathological changes of MS and observed pathological changes of GS fixed in formalin before finishing their experiment report. With paper prescription cases and pictures of MS and GS, clinicopathological discussions were also held in the course. Teachers used multimedia network equipment to demonstrate and explain the pathological changes of the MS and the GS, guiding students to observe and discuss. With the multimedia network equipment, processes and attention in pathology work, and the application
of frozen section examination, immunohistochemistry, fluorescence in situ hybridization, PCR, flow cytometry, and other new techniques were demonstrated.

Assessments
Each participant was informed that written examination, MS test, and GS test had to be taken to pass the course. In the written examination, all participants finished the same examination in 120 min, with a maximum score of 100. Each participant also utilized the microscope to observe pathological changes of 5 MS to provide a description of pathological changes and pathological diagnosis in 60 min, with a maximum score of 100. MS were the same for each participant. Twenty-five pictures of GS, which were also the same for each participant, were shown to test the observation abilities using GS. Participants were also required to write down corresponding pathological changes or pathological diagnosis of specimens in 30 min, with a maximum score of 100.

Participant performance during EC and CPCC was evaluated by two instructors, rating their performance on a ten-point scale that ranged from 1 to 5 (Table 3). The scale consisted of 10 items that specifically addressed student skills, knowledge, and their initiative of EC or CPCC.

Two five-point Likert scale questionnaires were used to evaluate participant perceptions of the efficacy of the three teaching modes, ranging from 1 (strongly disagree) to 5 (strongly agree). One questionnaire with 17 questions was used for the EC group and the CPCC group. Another with 29 questions was used for the combined EC and CPCC group (Table 4). Questionnaires were designed to investigate participant interest and attitude towards the curriculum, teaching mode, quality of specimens, content of the course, and pathology as a career choice. Examinations and evaluations were completed by participants and instructors immediately at the end of the course.

Statistical analysis
Scores of both written examinations and EC examinations of anatomy, histology, and embryology of all six classes’ students were statistically analysed using one-way ANOVA. One-way ANOVA was also used to analyse the three groups’ participant scores in pathology written examinations, MS test, and GS test. Participant performance in CPCC and EC, participant perceptions about CPCC and EC, and participant perceptions of different teaching content of EC or CPCC in different groups were analysed using one-way ANOVA or Kruskal-Wallis H test. A p-value < 0.05 was considered statistically significant. GraphPad Prism 7 (GraphPad software, La Jolla, CA, USA) was used for one-way ANOVA analyses. SPSS for Windows Version 13.0 (IBM SPSS, Chicago, IL) was used for Kruskal-Wallis H test.

Results/Analysis

Assessments
All students participated in the written examinations, MS and GS tests, and answered the structured questionnaire at the end of each course. Figure 1 depicts the academic results for comparisons of the written examinations and MS and GS test scores for the three groups. Compared to the EC group, mean scores of the written examination, MS test, and GS test of the other two groups were significantly higher. Meanwhile, the combined EC and CPCC group scores were significantly higher than the CPCC group as well (P< 0.05 or < 0.01).

Figure 1. Comparisons of the written examinations and specimen test scores for the three groups (n=60/group) (mean ± SD).
Notes: Analysed by one-way ANOVA. EC: experiment course, CPCC: clinical pathology clerkship course, GS: gross specimens, MS: microscopic slides.

*P < 0.05, compared with written examination scores of other two groups.

#P < 0.05, compared with microscopic slides test scores of other two groups.

▲P < 0.01, compared with gross specimens test scores of other two groups.

As presented in Table 3, for overall performance, CPCC group, participant performance of combined EC and CPCC group in EC or CPCC were better than the in the EC group (P < 0.01). CPCC group and participant performance of EC and CPCC group in CPCC were better than participant performance of EC and CPCC group in EC (P < 0.01). However, no significant difference was found in overall performance between the CPCC group and participant performance of EC and CPCC group in CPCC (P ≥ 0.05). With regard to each item, the CPCC group and participant performance of EC and CPCC group in EC or CPCC were significantly better than in the EC group, except in items four and seven (P < 0.05 or < 0.01). However, in items four and seven, the CPCC group and participant performance of EC and CPCC group in CPCC were still significantly better than in the EC group (P < 0.01). In addition, participants in the CPCC or CPCC of EC and CPCC group exhibited better performance in problem solving skills, engaged in course activity, exhibited initiative and curiosity to observe specimens and learn new techniques, and shared thoughts and opinions with their peers better than EC group and students of EC and CPCC group in EC (P < 0.01).

Table 3: Comparison of participant performances evaluated by instructors (n=60/group) (mean ± SD).
<table>
<thead>
<tr>
<th>Items</th>
<th>EC</th>
<th>CPCC</th>
<th>EC+CPCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Analytical and problem-solving skills</td>
<td>2.38±0.85*</td>
<td>3.73±1.01</td>
<td>3.05±1.21*</td>
</tr>
<tr>
<td>2. Demonstrates viewpoints of initiative and curiosity</td>
<td>2.45±0.87**</td>
<td>2.98±0.87</td>
<td>3.20±1.04</td>
</tr>
<tr>
<td>3. Be engaged in the course actively</td>
<td>2.70±0.79*</td>
<td>3.88±0.85</td>
<td>2.13±0.91*</td>
</tr>
<tr>
<td>4. Initiative and curiosity to observe specimens</td>
<td>1.93±0.78***</td>
<td>3.93±0.92</td>
<td>2.23±0.81***</td>
</tr>
<tr>
<td>5. The ability of observation to gross specimen</td>
<td>2.35±0.86*</td>
<td>3.13±0.85****</td>
<td>3.82±1.03</td>
</tr>
<tr>
<td>6. The ability of observation to microscopic slide</td>
<td>1.78±0.76*</td>
<td>2.38±0.85</td>
<td>3.22±0.96</td>
</tr>
<tr>
<td>7. Shares thoughts and opinions with peer actively</td>
<td>2.58±0.70***</td>
<td>4.00±0.66</td>
<td>2.88±0.88***</td>
</tr>
<tr>
<td>8. Mark of coursework</td>
<td>2.82±0.93*</td>
<td>3.35±0.86</td>
<td>3.73±0.97</td>
</tr>
<tr>
<td>9. Mark of quiz</td>
<td>2.18±0.85*</td>
<td>3.02±0.95</td>
<td></td>
</tr>
<tr>
<td>10. Initiative and curiosity to learn new technique applied in pathology</td>
<td>2.27±0.76**</td>
<td>3.52±1.02****</td>
<td>2.85±1.04</td>
</tr>
<tr>
<td>Overall performance</td>
<td>2.35±0.87*</td>
<td>3.39±1.01</td>
<td>2.99±1.10*</td>
</tr>
</tbody>
</table>

Notes: Analysed by one-way ANOVA. Coursework and quiz are same for each group. Participant overall performances evaluated by instructors (n=600/group). EC: experiment course, CPCC: clinical pathology clerkship course.

* P<0.01, compared with other three groups.
** P< 0.05, compared with other three groups.
*** P<0.01, compared with CPCC group or CPCC of EC and CPCC group.
**** P<0.01, compared with EC group or EC of EC and CPCC group.
▲ P< 0.01, compared with other two groups.

**Participant perception**

As presented in Table 4, participants in the CPCC and combined EC and CPCC groups showed more interested in pathology curriculum than those in the EC group (P< 0.01). They also more greatly recognized that pathology learning improved the effect of clinical learning (P< 0.01). Compared to the EC, participants seemed more interested in the CPCC (P< 0.01). Even within the combined EC and CPCC group, all participants showed more interested in the CPCC than in the EC (P< 0.01). Compared with the EC group, the CPCC participants had more initiative to choose pathologist as their career choice (P< 0.01). With regard to items seven to 11, participant perceptions of the CPCC were significantly higher than participant perceptions of the EC (P< 0.01). Participant felt that the CPCC was superior to the EC in improving their clinical learning, observing specimens, and studying pathological changes. Greater satisfaction with the course teaching content and process was higher for students in the CPCC than in the EC (P< 0.05). Items 13 to 17 showed the participants perceptions of the teaching content of the EC or the CPCC. CPCC participant perceptions of the teaching content of CPCC were significantly better than EC participant perceptions of the teaching content of EC (P< 0.01 or P< 0.05).

**Table 4: Comparison of participant perceptions of experiment course or clinical pathology clerkship course of different teaching modes (n=60/group) (mean ± SD).**
<table>
<thead>
<tr>
<th>Question</th>
<th>EC</th>
<th>CPCC</th>
<th>CPCC of EC and CPCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. You are very interested in pathology</td>
<td>3.25±0.88</td>
<td>3.80±1.02</td>
<td>4.25±0.82</td>
</tr>
<tr>
<td>2. You have acquired theoretical knowledge of pathology very well</td>
<td>2.80±0.88</td>
<td>3.38±0.85</td>
<td>3.63±0.92</td>
</tr>
<tr>
<td>3. It is very helpful to learn pathology for acquiring clinical knowledge</td>
<td>3.75±0.84</td>
<td>4.38±0.58</td>
<td>4.70±0.50</td>
</tr>
<tr>
<td>4. It is very helpful to learn pathology for cultivating clinical thinking</td>
<td>3.62±0.85</td>
<td>4.33±0.66</td>
<td>4.72±0.52</td>
</tr>
<tr>
<td>5. You want to be a pathologist as your career choice after graduated</td>
<td>1.80±0.88</td>
<td>2.60±1.09</td>
<td>2.75±1.10</td>
</tr>
<tr>
<td>6. You are very interested in this course</td>
<td>3.18±0.93</td>
<td>4.33±0.68</td>
<td>3.55±0.86</td>
</tr>
<tr>
<td>7. This course is very helpful for acquiring theoretical knowledge of pathology</td>
<td>3.57±0.87</td>
<td>4.37±0.69</td>
<td>3.67±0.86</td>
</tr>
<tr>
<td>8. This course is very helpful for acquiring clinical knowledge</td>
<td>3.82±0.77</td>
<td>4.55±0.53</td>
<td>3.93±0.73</td>
</tr>
<tr>
<td>9. This course is very helpful for cultivating clinical thinking</td>
<td>3.87±0.89</td>
<td>4.60±0.56</td>
<td>3.75±0.89</td>
</tr>
<tr>
<td>10. It's very easy to observe the specimens in this course</td>
<td>3.20±0.97</td>
<td>4.18±0.65</td>
<td>3.03±0.90</td>
</tr>
<tr>
<td>11. It's very easy to study pathological changes of specimens in this course</td>
<td>3.18±0.95</td>
<td>4.08±0.70</td>
<td>3.67±0.71</td>
</tr>
<tr>
<td>12. The teaching content and process of this course are well designed</td>
<td>3.57±0.87</td>
<td>4.35±0.58</td>
<td>3.15±1.09</td>
</tr>
<tr>
<td>13. You are very interested in the clinicopathological discussion</td>
<td>3.87±0.62</td>
<td>4.80±0.40</td>
<td>3.15±0.82</td>
</tr>
<tr>
<td>14. You are very interested in observing gross specimens</td>
<td>2.92±0.87</td>
<td>4.48±0.60</td>
<td>2.52±0.87</td>
</tr>
<tr>
<td>15. You are very interested in observing microscopic slides</td>
<td>2.48±0.72</td>
<td>4.25±0.63</td>
<td>2.32±0.77</td>
</tr>
<tr>
<td>16. You are very interested in frozen section examination and new techniques</td>
<td>2.37±0.74</td>
<td>3.67±0.71</td>
<td>2.45±0.77</td>
</tr>
<tr>
<td>17. You are very interested in processes and attentions in pathology work</td>
<td>2.38±0.78</td>
<td>3.47±0.72</td>
<td>2.17±0.69</td>
</tr>
</tbody>
</table>

Notes: Analysed by one-way ANOVA. EC: experiment course, CPCC: clinical pathology clerkship course.

▲P< 0.01, compared with other two groups.
▲▲P< 0.05, compared with other two groups.
*P<0.01, compared with CPCC group or CPCC of EC and CPCC group.
**P<0.01, compared with other three groups.
***P<0.05, compared with other three groups.

As shown in Figure 2, in all participants, compared with the EC group, more CPCC participants strongly agreed or agreed that the CPCC was very helpful for their pathology and clinical learning and that pathologist would be their career choice after graduation (P< 0.01). In addition, more participants strongly agreed or agreed that it was very easy to observe specimens and study pathological changes of specimens, that the course was well designed to help them study and that they were more interested in the teaching content in the CPCC than in the EC (P< 0.01).

Figure 2. Participant perception of experiment course or clinical pathology clerkship course in different teaching modes (n=60/group).
a. Participant perception of experiment course in experiment course group

b. Participant perception of clinical pathology clerkship course in clinical pathology clerkship course group

c. Participant perception of experiment course in experiment course and clinical pathology clerkship course group
Participant perception of clinical pathology clerkship course in experiment course and clinical pathology clerkship course group

Notes: Analysed by Kruskal-Wallis H test. The 17 items in the questionnaire ranges from strongly disagree to strongly agree. The full descriptors are displayed in Table 4. Numbers of respondents are shown in the corresponding areas.

*P<0.01, compared between the 3 groups.
**P<0.01, compared between the 4 groups.

Figure 3 depicts a comparison of participant perceptions of different teaching content of the EC or the CPCC in different teaching modes. The clinicopathological discussion was the most appreciated subject for all participants (P<0.05), but there were no significant differences between the clinicopathological discussion and observing GS in the combined EC and CPCC group participant perceptions of the CPCC (P>0.05). Comparing different teaching content within each course, observing MS, frozen section examination and new techniques, processes and attention in pathology work were in the last (P< 0.05), and there were no significant differences between them (P>0.05). In addition, participant perceptions of observing GS and MS both ranked second compared with other content in the
Figure 3. Comparisons of participant perception of teaching content of different teaching modes (n=60/group) (mean ± SD).

Notes: Analysed by one-way ANOVA. EC: experiment course, CPCC: clinical pathology clerkship course.
*P< 0.05, compared with other content of same course.
#P<0.05, compared with clinicopathological discussion, frozen section examination and new techniques, processes and attentions in pathology work of same course.
▲P< 0.05, compared with observing microscopic slides, frozen section examination and new techniques, processes and attentions in pathology work of same course.

Discussion

Students no longer attend practical classes or look in microscopes. Instead, computer-assisted teaching has flourished, and web-based learning is now the norm worldwide. There is little doubt that virtual microscopy, virtual slides, and web-based learning contribute greatly to pathology teaching and learning (Domizio, 2006; KUMAR et al., 2010; Szymas and Lundin, 2011). However, there are still key limitations in the application of these methods, such as lack of funds and techniques, especially in developing countries (Dee, 2009; Paulsen, Eichhorn and Bräuer, 2010; Lmj, Goldman and Hortsch, 2018). The number of consented autopsies, which has been in decline for some time, has fallen even further, so that autopsy demonstrations have now become exceedingly rare (Domizio, 2006), resulting in deleterious effects on the renewal of GS and MS preparations used for teaching. There is no doubt that pathology instructors must explore new methods for teaching pathology in order to raise the profile for undergraduate curriculum back to somewhere near its former level.

In our study, using CPCCs, pathology teaching and learning greatly benefited from increased exposure to clinical
pathology and application of specimens with typical pathological changes. These methods improved student interest in pathology curriculum, student performance, and perceptions of the course. Meanwhile, we can also closely combine theoretical knowledge with clinical cases to achieve mastery through a comprehensive study of pathology knowledge, to cultivate clinical thinking and improve the quality of teaching.

Pathology is identified to be a unpopular residency choice for medical students worldwide(Jason C Ford, 2010; Hung and Jarvis, 2011). A survey revealed that since they prefer direct patient contact, most of clinical residents reject pathology as their career choice. This survey also demonstrated that the second most common reason for rejecting pathology was insufficient or inadequate contact with pathology or pathologists in medical school(Jason C Ford, 2010). In contrast, for pathology residents, one of the main reasons offered for choosing pathology is positive pathology experiences in medical school(Jason C Ford, 2010). Clinical residents propose several other misconceptions and stereotypes about pathology, including misunderstanding about the role of pathologists and pathology practice. Pathology seems to be boring and/or repetitive for them. (Jason C Ford, 2010). The reasons for why clinical residents reject pathology careers may provide clues to improve pathology resident recruitment(Jason C Ford, 2010). Clinical residents also discussed three types of insufficient or inadequate contact with pathologists: minimal exposure to pathologists, poor teaching from pathologists (or socially awkward, negative role models in pathology), and pathology exposure being too late to influence residency selection(Jason C Ford, 2010). Taken all, pathology departments should be more aggressive about early exposure to pathology through clinical pathology clerkships courses to affect early residency selection. Pathologists can perform this new courses to increase medical students interest in pathology and improve pathology recruitment (Jason C Ford, 2010).

Students in another study also provided several other explanations for rejecting pathology, including its presumed introversion, a series of negative stereotypes, and perceptions about the medical authenticity of a pathology career, but the most important and interesting reason for rejecting pathology is that pathology is invisible. In other words, pathology is not so much rejected as simply ignored(Hung and Jarvis, 2011). Thus, departments of pathology must make pathology more visible to students and show them how pathologists contribute to clinical care.

According to those studies, early exposures to pathology and better promotion of pathology clerkship are important steps in improving residency recruitment. Unfortunately, there is little formal exposure to the practice of pathology worldwide(Margret S Magid and Cambor, 2012). Although electives in pathology have been widely available, if students reject these classes, they lack the required exposure to pathology practice in medical school, causing this practice to seem not directly related to patient care(Margret S Magid and Cambor, 2012). With the CPCC, we hope that students can improve their interest in pathology, as shown in our study and also not continue to perceive pathology as invisible. Furthermore, we hope that students will choose their residencies using CPCCs to preview their options, helping pathology recruitment to benefit from having more students preview pathology to recruit more medical students into this field.

Our study shows that compared with participants who only received traditional the EC, the CPCC participants showed more interest in pathology and stronger will to be a pathologist as their career choice after graduation. However, there is a limitation to our study: participants are still second year undergraduates. In the next three years, they will continue to study other disciplines, including clinical disciplines, so their final choices are still uncertain.

Pathology in medical education has traditionally been assigned to the preclinical years as a component of the basic science curriculum (Margret S Magid and Cambor, 2012; Margret S. Magid et al., 2015). The preclinical pathology education focuses on principles of pathogenesis and morphology, which are essential to understand the disease. Furthermore, pathology is also a clinical discipline as well as a basic science discipline. It contributes greatly to patient care(Margret S. Magid et al., 2015). A survey shows that with traditional pathology education, there is an
important deficit in some forms of clinical experience that can result in inappropriate use of pathology and laboratory services by future clinicians in patient care (Talbert et al., 2009). Pathology is one of the key disciplines of diagnostics, with great contributions to patient care and therapy management. Medical students must be trained to understand the proper interactions with clinical and pathology to know practical considerations, including what potential information pathology can provide, the intrinsic limitations of pathology, the optimal methods for specimen preparation and delivery for evaluation (Margret S Magid and Cambor, 2012; Jason Ford and Pambrun, 2015; Margret S. Magid et al., 2015). Another valuable perspective obtained from exposure to clinical pathology is that pathologists are professional colleagues who partner with the clinician in patient care and therapy management. Thereby, pathologist should deserve the same respect as any clinical consultant (Margret S Magid and Cambor, 2012).

Increased exposure to pathology will positively improve the way that future surgeons, internists, and neurologists know the field of pathology. Additionally, patient care and therapy will benefit a lot from the increased exposure to pathology (Minhas et al., 2017). However, if the medical students have never seen the practical process of pathology, future clinicians will send specimens to pathology without any thought about the specimens after they leave the clinic or operating room. The clinicians have no idea of the timeline for receiving, fixing, gross examination, and preparation of a specimen, or of the turnaround time for ordering immunohistochemistry or other ancillary techniques, such as fluorescence in situ hybridization or genetic sequencing (Minhas et al., 2017). The CPCC with strong and direct demonstration of the processes, attentions, quality control standards, and new techniques in pathology would ensure appropriate use of pathology services by future clinicians, thereby improving patient care. Through the CPCC, students can be educated in proper interactions with pathologists/clinical laboratory scientists in pathology and laboratory medicine. They can better understand practical implications for patient assessment and management, such as what potential information pathology services can provide, the intrinsic limitations of various clinical tests, optimal ways that specimens should be prepared and delivered for evaluation, and reasonable expectations for turnaround time. The CPCC, with strong instruction for pathology, would ensure appropriate use of pathology services by future clinicians, thereby benefiting patients everywhere.

**Conclusion**

According to our study, we conclude that in addition to improving pathology education, there are several major benefits that would be served by CPCCs in the practice of pathology and laboratory medicine. First, medical students would derive knowledge and skills in effective utilization of those services of pathology and laboratory tests for optimal patient care. Second, future clinicians would develop applied knowledge on the role of pathologists as professional colleagues who provide valuable consultation in patient care. Finally, students would develop knowledge about the daily practice of pathology that would contribute to their consideration of pathology as a future career choice. Based on this study, we will continue to conduct further research to determine whether CPCCs improve student performance in those disciplines that are closely connected to pathology, such as surgery and gynaecology. Even when participants have graduated from medical school in three to four years, we hope to continue this study to examine the effects of the CPCC contributions to students’ final career choice, especially with respect to pathology residence.

**Take Home Messages**

- Clinical pathology clerkship course greatly improve students’ interest in pathology
Clinical pathology clerkship course greatly improve students’ pathology learning
Specimens observation greatly benefit from Clinical pathology clerkship course
Clinical pathology clerkships contribute greatly to pathology education
Clinical pathology clerkship course may improve pathology resident recruitment

Notes On Contributors

Siyuan Gan: lecturer of Pathology, Department of Pathology, Guangdong Medical University. ORCiD: https://orcid.org/0000-0002-3382-0887

Rujia Li: lecturer of Pathology, Department of Pathology, Guangdong Medical University.

Yanping Ha: lecturer of Pathology, Department of Pathology, Guangdong Medical University.

Zhenning Zou: lecturer of Pathology, Department of Pathology, Guangdong Medical University.

Ruifang Ye: Postgraduate student of Pathology, Guangdong Medical University.

Wei Jie: Professor of Pathology, Department of Pathology, Guangdong Medical University.

Xiaoqing Di: Pathologist, the Pathological Diagnosis and Research Centre, the Affiliated Hospital of Guangdong Medical University.

Wenhua Hu: Pathologist, the Pathological Diagnosis and Research Centre, the Affiliated Hospital of Guangdong Medical University.

Yanqin Sun: Associate Professor of Pathology, Department of Pathology, Guangdong Medical University. ORCiD: https://orcid.org/0000-0002-0322-0100

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Bibliography/References


**Appendices**

None.

**Declarations**

_The author has declared that there are no conflicts of interest._

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**Ethics Statement**

The study obtained verbal consent from study participants. Participation was voluntary. Participants were informed about the aim and methods of the study and were explicitly asked to provide permission for the study. This informed consent was required before we could start the study. Participants could stop their participation in the study at any
time. The data for this study was processed anonymously and data of individual respondents is not traceable in the presented results. Since the study was an educational activity, and the participants were not allowed to conduct any practical work or operations that might affect the pathology diagnose in the clinical pathology clerkships courses, the Institutional Ethical Review Board of the affiliated hospital Guangdong Medical University confirms that ethics approval was not required.

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