Methods

Introduction

In clinical practice, gastroendoscopy (GS) procedures are performed by both gastroenterologists (GE) and hepatologists (HT) in many countries. An increased demand for endoscopic procedures has led to the provision of these services without satisfactory quality assessment methods [1]. The importance of performing high-quality endoscopic procedures has increased [2], in particular to prevent acquired infections after the procedures [3–6]. In GS, endoscopic biopsy (EBx) remains the gold standard for the investigation and documentation of esophageal, gastric and duodenal pathology [7]. EBx is subjective performed by an endoscopist, and the level of skill and experience of the endoscopist may affect the quality of the endoscopic service. Reasons for this discrepancy included lack of experience practitioners to order EBx when required of GS issues between in GE and HT limit access. Ideally, services should be safe and of high quality. This study assessed the EBx/GS ratio as the endoscopic quality assurance as an index of GS services. This was a cohort study of endoscopists at Kaohsiung Chang Gung Memorial Hospital, a teaching hospital in southern Taiwan. There were 34,570 episodes of EBx in 199,877 GS procedures. The 25 endoscopists were divided into GE (n = 13) and HT (n = 12) groups, and correlation coefficients were calculated over a 14.5-year duration of intervention. The Trimmean of EBx/GS was 19.29% in 14.5 years (34570/199877 with Trimmean 0.2 percentile ratio correlations), and the Pearson correlation coefficient was 0.90229. There were significantly more EBx procedures in the GE group than in the HT group at 1 and 5 years (21.5% vs. 15.1% and 20.9% vs. 17.3%, respectively, P<0.00001). Junior GE attempted significantly more EBx than both the senior GE (24.06% vs. 20.41%, P<0.0001), and junior HT (24.06% vs. 13.2%, P<0.001). In conclusion, quality assurance for gastrointestinal endoscopy involves numerous aspects of unit management and patient safety. Quality measures used with the EBx/GS ratio may be one of the best ways to ensure the quality of endoscopic procedures in a teaching hospital.
**Table 1. Indications for upper endoscopies for the gastroenterologists and hepatologists.**

| Indications for endoscopy* | GE (%) | HT (%) | P value |
|----------------------------|--------|--------|---------|
| UGI bleeding               | 2597 (1.1) | 911 (0.9) | <0.0001 |
| PU                         | 149 (0.1) | 142 (0.1) | 0       |
| Esophagus                  | 7716 (3.4) | 5037 (4.9) | <0.0001 |
| GERD                       | 4786 (2.1) | 2348 (2.3) | <0.0001 |
| Ulcer                      | 2584 (1.1) | 525 (0.5) | <0.0001 |
| Polyp                      | 1016 (0.4) | 278 (0.3) | <0.0001 |
| Submucosa tumor            | 1421 (0.6) | 258 (0.3) | <0.0001 |
| Varices                    | 10523 (4.6) | 6686 (6.6) | <0.0001 |
| Mallory Weiss              | 188 (0.1) | 12 (0.0) | <0.0001 |
| Hiatus herniation          | 5907 (2.6) | 1488 (1.5) | 0       |
| Achalasia                  | 403 (0.2) | 30 (0.0) | <0.0001 |
| Barrett                    | 991 (0.4) | 158 (0.2) | <0.0001 |
| Other                      | 5933 (2.6) | 488 (0.5) | 0       |
| Stomach                    | 57055 (24.9) | 21822 (21.4) | 0       |
| Gastritis                  | 24982 (10.9) | 17613 (17.3) | <0.0001 |
| Ulcer                      | 30477 (13.3) | 14571 (14.3) | 0       |
| Cancer                     | 1610 (0.7) | 708 (0.7) | <0.0001 |
| Polyp                      | 6441 (2.8) | 3041 (3.0) | <0.0001 |
| Submucosa tumor            | 4719 (2.1) | 1021 (1.0) | 0       |
| Lymphoma                   | 312 (0.1) | 64 (0.1) | <0.0001 |
| Chronic Gastritis          | 9230 (4.0) | 1316 (1.3) | 0       |
| Varices                    | 3354 (1.5) | 2093 (2.1) | <0.0001 |
| Angiodyplasia              | 933 (0.4) | 292 (0.3) | <0.0001 |
| Xanthoma                   | 2058 (0.9) | 927 (0.9) | <0.0001 |
| Marginal ulcer             | 836 (0.4) | 420 (0.4) | <0.0001 |
| Stomal gastritis           | 1246 (0.5) | 880 (0.9) | <0.0001 |
| PHG                        | 976 (0.4) | 1462 (1.4) | <0.0001 |
| Endoscopic treatment       | 2002 (0.9) | 909 (0.9) | <0.0001 |
| EVL                        | 1295 (0.6) | 909 (0.9) | <0.0001 |
| Other                      | 5068 (2.2) | 1534 (1.5) | 0       |
| Duodenum                   | 19356 (8.5) | 9813 (9.6) | 0       |
| Ulcer                      | 287 (0.1) | 80 (0.1) | <0.0001 |
| Endoscopic treatment       | 312 (0.1) | 64 (0.1) | <0.0001 |
| Lymphoma                   | 12129 (5.3) | 3911 (3.8) | 0       |
| Total                      | 228892 (100.0) | 101811 (100.0) | 0       |

*Indications can be more than one selection for each case.

PHG: portal hypertensive gastropathy; PU: peptic ulcer; UGI: upper gastrointestinal; EVL: esophageal varices ligation; GE: gastroenterologist; GERD: gastroesophageal reflux disease; HT: hepatologist.

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endoscopic biopsy, and all cases stopped spontaneously or by endoscopic hemostasis.

**Ethics Statement**

All clinical investigations were conducted according to the principles expressed in the Declaration of Helsinki. Written informed consent was obtained from all participants for their information to be stored in the hospital database and used for research. This study was approved by the Institutional Review Board of Chang Gung Memorial Hospital Ethics Committee (No.102-2299B).

**Statistical Analysis**

All statistical analyses were performed using the Trimmean method of Microsoft Office Excel 2007 with percent = 0.2. A mean trimmed 20% was computed by discarding the lower and higher 10% of the scores and taking the mean of the remaining scores (http://www.java2s.com/Tutorial/Microsoft-Office-Excel-2007/0420__Statistical-functions/TRIMMEANarraypercentreurnsthemeanoftheinteriorofdataset.htm), and Pearson correlation coefficient analysis was performed (http://www.java2s.com/Tutorial/Microsoft-Office-Excel-2007/0420__Statistical-functions/PEARSONindependentdependentreturnsthPearsonproductmomentcorrelationcoefficient.htm) to create standard quality assurance curves of EBx/GS linear correlation with 95% mean prediction intervals. Comparisons of parameters of the EBx/GS ratio between 1-year and 5-year investigations of the GE and HT were performed using the X² test, Fisher’s exact test, and Student’s t-test with SPSS software (version 12.0; SPSS, Chicago, IL, USA). P values less than 0.05 were considered to be statistically significant.

**Results**

The ratio of EBx/GS was 17.29% (34570/199877, mean biopsy rate 19.87±8.14%) for the 27 endoscopists over the 14.5-year study period. The Pearson correlation coefficient was 0.90229. The Trimmean of EBx/GS was 19.29% (34570/199877 over 14.5 years) with Trimmean 0.2 percentile ratio correlation, R² = 0.8141 (27, 0.2) (Figure 1) (Table 2). In 1-year and 5-year investigations, the ratio of EBx/GS was significantly higher in the GE group than in the HT group (21.5% vs. 15.1% and 20.9% vs. 17.3%, respectively, P<0.00001) (Table 2). There were no significant differences between the 1-year and 5-year analyses in both the GE and HT groups (Table 2). In the 5-year analysis with the 25 endoscopists, there were significantly more EBx procedures in the GE group than in the HT group (20.9% vs. 17.3%, P<0.0001) (Table 3). The junior GE attempted significantly more EBx procedures than both the senior GE (24.1% vs. 20.4%, P<0.0001) and the junior HT (24.1% vs. 13.2%, P<0.0001) (Table 3). For the HT group, the EBx/GS was significantly higher for the senior than the junior physicians (18.3% vs. 13.2%, P<0.0001) (Table 3). According to the indications for endoscopy (Table 1), the discrepancies between the GE and HT groups were significantly different, especially in esophageal varices, gastric varices and portal hypertensive gastropathy.

**Discussion**

Kaohsiung Chang Gung Memorial Hospital is a medical center with 2,715 beds and over 6,900 outpatients and 370 emergency patients. To deliver a high quality medical service, the Hospital adopts a patient-centered approach, safety practices, and encourages innovations in teaching, research and medical services. In this large academic medical cohort study, the average biopsy rate was 17.3% of about 200 thousand endoscopic procedures over a 14.5-year period. Because of differences in EBx for each endoscopist, an appropriate statistical method was used to represent the accuracy, and showed a statistical average of the EBx/GS of 19.87±8.24% with a confidence correlation coefficient of 0.90229. According to the Pearson correlation coefficient, the rate of EBx was statistically related to the GS service. For draw up a standard assurance in
endoscopic procedural practice, Trimmean modified with Trimmean statistical method was used to discard the variant data for some endoscopists. A recent study showed that more attending physicians (42%) than fellows (40%) felt that writing a manuscript and belonging to a gastrointestinal society improved knowledge, however the fellows expressed that they needed more practice [8]. In the current study, the higher biopsy ratio for the junior GE (24%) than the senior GE showed that pathological findings can improve experience. That is, the junior GE needed more pathological diagnoses to contribute to the endoscopic findings. In contrast, the lower biopsy ratio for the junior HT (13.2%) than the senior HT (18.3%) suggests a lack of subjective clinical alertness to perform a biopsy, and that the clinical experience of senior HT in interpreting endoscopic findings may not be sufficient. With regards to the indications for the endoscopic procedures, the causes were similar in the two groups. It should be noted that the hepatologists may have been looking for varices and therefore less likely to be taking biopsies in patients with dyspepsia. The large variation in EBx/GS ranging from 8.64% to 44.58% makes it difficult to calculate a confident mean. A mean trimmed by 20% is computed by discarding the lower and higher 10% of the scores and taking the mean of the remaining scores. The Trimmean (27, 0.2) of this study was 19.29%, and the R² value was 0.8141, showing that a 19.3% EBx rate was a quality assurance reference for daily clinical GS services. This is a simple method to calculate a reference mean from a large endoscopic unit for endoscopic assurance of quality. There was no evidence to suggest that a higher EBx/GS mean (44.58%) from the senior GE contributed to better results for the early detection of cancer than the HT or junior GE. If there is no apparent reason for this discrepancy, it is a so-called aberration of waste medical resources. Stand on the physician education that it may be an evidence of the

![Figure 1. The ratio of the 34,570 endoscopic biopsies and 199,877 gastroendoscopic services with Trimmean (0.2 percent) correction performed by 27 endoscopists including 15 gastroenterologists and 12 hepatologists over 14.5 years. doi:10.1371/journal.pone.0078557.g001](image)

Table 2. The ratio of endoscopic biopsy/gastroendoscopic procedures and Trimmean modified with Trimmean statistical method of Microsoft Office Excel 2007 between the gastroenterologists and hepatologists.

| Category | Gastroenterologist (n = 13) | Hepatologist (n = 12) |
|----------|-----------------------------|-----------------------|
|          | EBx | GS | Ratio (%) | Trimmean (%) | EBx | GS | Ratio (%) | Trimmean (%) |
| 1 year   | 2261 | 10503 | 21.5<sup>a</sup> | 22.23 | 775 | 5149 | 15.1<sup>a</sup> | 16.50 |
| 5 years  | 11185 | 53492 | 20.9<sup>b</sup> | 22.36 | 4446 | 25679 | 17.3<sup>b</sup> | 16.97 |
| 14.5 years* | EBx/GS = 34570/199877, (ratio = 17.29%), (mean = 19.87±8.14%), (Trimmean = 19.29%) |

Statistic analysis used with Trimmean method of Microsoft Office Excel 2007 with percent = 0.2. A mean trimmed 20% was computed by discarding the lowest and highest 10% of the scores and taking the mean of the remaining scores.

*Total 27 endoscopists included 15 gastroenterologists and 12 hepatologists; The Pearson correlation coefficient was 0.90229; EBx = endoscopic biopsy; GS = gastroendoscopy;

<sup>a</sup> <sup>b</sup>P < 0.0001.

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deviant behavior with medical waste. Educating physicians is an essential step in establishing a broader culture of compliance and improved integrity in a healthcare system, extending beyond Medicare and Medicaid [9–10]. Therefore, this behavior needs to be corrected [11]. In contrast, a lower EBx/GS mean down to 8.64%, the endoscopic unit staff should have in charge to make a sense or alarm to correct or review the malpractice for the patient safety in a large academic teaching hospital because of the risky for missing diagnosis. How to measure the assurance of the endoscopic service is very important [12–14]. Therefore, the value of the present study is in suggesting the mean EBx/GS as a guideline to cover both GE and HT in the clinical endoscopic service. We also attempted to calculate an acceptable range in 95% mean prediction interval with ±5% distribution for the clinical reference as a standard quality assurance curve. The $R^2$ was equal to 0.43 (Figure 2). Our results suggest that a ratio of EBx/GS of 19.3±5% (range 14.3% to 24.3%) should be followed by not only GE but also HT in the quality investigation of endoscopic services. There was no significant difference in mean EBx/GS between the 1-year and 5-year observations. Annual endoscopic services. There was no significant difference in mean EBx/GS of 19.3 ± 5% (range 14.3% to 24.3%) should be followed by not only GE but also HT in the quality investigation of endoscopic services. There was no significant difference in mean EBx/GS between the 1-year and 5-year observations. Annual endoscopic services.

Table 3. The 5-year endoscopic biopsy/gastroendoscopy ratio of the 25 endoscopists including 13 gastroenterologists and 12 hepatologists and the distribution of senior and junior physicians in our unit.

|                | Gastroenterologist | Hepatologist |
|----------------|--------------------|--------------|
|                | EBx    | GS   | %   | EBx    | GS   | %   |
| Senior         |        |      |     |        |      |     |
| 1              | 1077   | 2416 | 44.6| 1      | 579  | 2060| 28.1|
| 2              | 1530   | 5334 | 28.7| 2      | 401  | 1712| 23.4|
| 3              | 711    | 2848 | 25.0| 3      | 406  | 1791| 22.7|
| 4              | 965    | 4140 | 23.3| 4      | 778  | 4043| 19.2|
| 5              | 1170   | 6120 | 19.1| 5      | 595  | 3304| 18.0|
| 6              | 1318   | 7452 | 17.7| 6      | 216  | 1344| 16.1|
| 7              | 886    | 5613 | 15.8| 7      | 212  | 1377| 15.4|
| 8              | 792    | 5415 | 14.6| 8      | 415  | 2859| 14.5|
| 9              | 973    | 6825 | 14.3| 9      | 199  | 2303| 8.6 |
| Junior         |        |      |     |        |      |     |
| 10             | 199    | 612  | 32.5| 10     | 253  | 1600| 15.8|
| 11             | 717    | 3017 | 23.8| 11     | 168  | 1234| 13.6|
| 12             | 712    | 3101 | 23.0| 12     | 224  | 2052| 10.9|
| 13             | 135    | 599  | 22.5| 13     |      |     |
| Total          | 11185  | 53492| 20.9|        | 4446 | 25679| 17.3* |
| All seniors    | 9422   | 46163| 20.4*|        | 3801 | 20793| 18.3* |
| All juniors    | 1763   | 7329 | 24.1*|        | 645  | 4886 | 13.2* |

EBx: endoscopic biopsy; GS: gastroendoscopy; *p<0.0001.

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In conclusion, quality assurance for gastrointestinal endoscopy involves numerous aspects of unit management and patient safety. Quality measures used with the EBx/GS ratio may be one of the best ways to ensure the quality of endoscopic procedures in a teaching hospital. The acceptable mean of EBx/GS was 19.3% ranging from 14.3% to 24.3% in 1-year evaluations.
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Author Contributions

Conceived and designed the experiments: KWC. Performed the experiments: KWC. Analyzed the data: KWC SSC. Contributed reagents/materials/analysis tools: KWC SSC. Wrote the paper: KWC SSC. Read and approved the final version of this manuscript: KWC SSC.

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Figure 2. The 5-year ratio of endoscopic biopsies and gastroendoscopic services with 95% mean prediction interval to create a standard quality assurance curve with ±5% border distribution. doi:10.1371/journal.pone.0078557.g002