Validation of the Diagnostic Score for Acute Lower Abdominal Pain in Women of Reproductive Age

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1. Background

Abdominal pain is one of the most common chief complaints of emergency department patients. It was the main symptom of 12.1% to 20.4% of noninjury visits to emergency departments of USA, and 16.8% to 17.8% of them were in severe conditions [1]. It is difficult to diagnose the causes of abdominal pain in some patients. Diagnosis of acute appendicitis, for example, was less accurate in young adult females than in males. The accuracies of diagnosis of acute appendicitis in young adult females were 71.7% to 75.3%, while the accuracies in male were 88.6% to 90.0% [2]. Diagnosis of acute lower abdominal pain in young adult females was particularly difficult due to overlapping symptoms of obstetrics and gynecological conditions with those of acute appendicitis. Negative appendectomies often occurred mostly from missed diagnoses of obstetrics and gynecological conditions [3].

CT scan improved accuracy in diagnosing appendicitis and can detect other causes of abdominal pain in female patients [4]. The use of CT scan can reduce negative appendectomies [5]. However, the universal use of CT scan for diagnosing appendicitis may not be cost-effective in global budget scheme reimbursement for healthcare [6].

Although ultrasound is not as accurate as CT scan, it also showed benefit in diagnosing acute lower abdominal pain [7, 8], especially for pregnant women and children, whom
radiation is relatively contraindicated. However, ultrasound alone had low sensitivity in the diagnosis of appendicitis. Its sensitivity was not more than unaided-clinical judgment [9].

Clinical prediction rules, through which clinical findings were systematically applied to predict difficult clinical conditions [10], may be another approach for the diagnosis of acute lower abdominal pain in females of reproductive age. Alvarado's score, although intentionally developed for early diagnosis of acute appendicitis [11], has been studied for admission criteria [12] or criteria for CT scan [13]. However, appendicitis scores were not adequately applicable to abdominal pain in females of reproductive age, because they could not detect obstetrics and gynecological causes. We, therefore, developed a clinical scoring for the diagnosis of acute lower abdominal pain in these particular patients [14]. In this study, we aimed to validate our clinical scoring with patients in a different time period.

2. Method

2.1. The Scoring System. The score is comprised of simple clinical findings, laboratory results, and a constant. Item scores were assigned for guarding or rebound tenderness, pregnancy (either by clinical or urine pregnancy test), tenderness at right lower quadrant of abdomen, tenderness at left lower quadrant of abdomen, leukocytosis (white cell count ≥ 10,000/µL), predominance neutrophil ≥75% in complete blood count, and a constant. The assigned scores and algorithm for diagnostic prediction were shown (Table 1). The item scores had both positive and negative values, which reflected an increase or a decrease in probabilities of the corresponding diagnoses when presenting with those clinical findings.

2.2. Validation Data. The setting hospital is Nakornping Hospital, a tertiary care hospital in Chiang Mai, Thailand. Validation data were extracted from the medical records of female patients aged 15–50 years who were admitted to surgical department or obstetrics and gynecology department during January and July 2009 with a chief complaint of acute lower abdominal pain within 14 days. Patients were classified into three groups upon their final professional diagnoses, which were (1) acute appendicitis (ICD10 code K-35); (2) obstetrics and gynecological conditions (OB-GYNc), including ectopic pregnancy (ICD10 code O-00), pelvic inflammatory disease (ICD10 code N70), and complicated ovarian cyst (ICD10 code N83); and (3) nonspecific abdominal pain (NSAP) (ICD10 code A09, K57, and R10 or other causes of abdominal pain). Study variables were age, marital status, duration of pain, presence of shifting of pain, nausea and vomiting, pregnancy, abnormal vaginal bleeding, presence of fever, systolic blood pressure, site of abdominal pain, presence of guarding or rebound tenderness from abdominal examination, result of complete blood count, and urine pregnancy test. Item scores were calculated and diagnostic prediction was performed for each patient. Final professional diagnoses in the medical records were considered as the reference standard for testing of the score accuracy.

2.3. Statistical Analysis. Patients' characteristics of the development data and the validation data were summarized. Score predicted diagnosis of each patient was compared with final professional diagnosis. Diagnostic indices were calculated in the validation data. The abilities to discriminate appendicitis and OB-GYNc, in terms of areas under the receiver operating curves of the two data sets, were compared with the test for equality of two ROC curves. The positive likelihood ratios for the diagnosis of appendicitis and OB-GYNc of the development data and the validation data were tested with chi-squared for homogeneity test. The probability curves of appendicitis score and OB-GYN score were estimated from logistic regression postestimation function on actual rates of appendicitis and OB-GYNc in the development data and validation data.

2.4. Ethics. The study was approved by the Ethical Committee of Nakornping Hospital and the Ethical Committee of the Faculty of Medicine, Chiang Mai University.

3. Results

The patients' characteristics of the derivation data and the validation data were similar (Table 2). Appendicitis was the most common diagnosis in both data sets (70.5% in
Table 2: Demographic and clinical characteristics of patients in the development data set and validation data set.

| Characteristics                          | Development (n = 542) | Validation (n = 302) |
|-----------------------------------------|-----------------------|----------------------|
| Age (year)                              | Mean (SD) 29.9 (10.7) | 29.4 (10.3)          |
| Single (%)                              | 51.1                  | 56.0                 |
| Duration of pain (hr)                   | Mean (SD) 35.4 (41.4) | 36.9 (47.2)          |
| Shifting of pain (%)                    | 29.3                  | 16.6                 |
| Nausea and vomiting (%)                 | 43.4                  | 42.7                 |
| Abnormal vaginal bleeding (%)           | 5.7                   | 4.6                  |
| Diarrhea (%)                            | 8.5                   | 8.9                  |
| Temperature ≥ 37.5°C (%)                | 28.3                  | 35.3                 |
| Pulse rate (/min)                       | Mean (SD) 89.6 (16.1) | 89.7 (14.7)          |
| Systolic blood pressure (mmHg)          | Mean (SD) 119.6 (16.6)| 122.2 (16.6)         |
| RLOQ tender (%)                         | 91.9                  | 91.7                 |
| LLQ tender (%)                          | 12.7                  | 18.5                 |
| Guarding/rebound tenderness (%)         | 55.7                  | 54.0                 |
| Hematocrit (%)                          | Mean (SD) 37.0 (4.9)  | 36.5 (4.6)           |
| WBC (μL)                                | Mean (SD) 13266.1 (4928.0) | 12811.3 (4639.4) |
| Neutrophil (%)                          | ≥75 (%) 56.9          | 62.3                 |
| Pregnant/positive pregnancy test (%)    | 10.5                  | 12.6                 |

development data and 65.2% in validation data). The final diagnoses of patients were shown (Table 3).

When comparing the score-predicted diagnoses and the final professional diagnoses in patients from the validation data, the score correctly diagnosed 24 of 33 NSAP patients (72.7%), 181 of 203 appendicitis patients (89.2%), and 46 of 66 OB-GYN patients (69.7%). The overall accuracy of the score was 83.1% (251/302) (Table 4). The score had a sensitivity of 91.9%, a specificity of 79.0%, and a positive likelihood ratio of 4.39 for diagnosis of appendicitis. For the diagnosis of OB-GYN, the score had a sensitivity of 73.0%, a specificity of 91.6%, and a positive likelihood ratio of 8.73, respectively. The diagnostic indices and their 95% confidence intervals were displayed (Table 5).

When using the criteria in Table 1 for prediction of diagnoses, the performance of the score in discrimination of appendicitis in terms of ROC analysis and positive likelihood ratio in the validation data were not significantly different from those in the development data. The area under ROC curve for the discrimination of appendicitis and “nonappendicitis” was 0.855 in the validation data and 0.796 in the development data (P = 0.068). The positive likelihood ratios for diagnosis of appendicitis in the validation data and the development data were 4.39 and 2.97, respectively (P = 0.100). The areas under ROC curves for the discrimination of OB-GYN and “non-OB-GYNc” were not different in the validation data and the development data (0.823 and 0.808; P = 0.706). The ROC areas of the development data reported in this study were different from those reported in our previous study because in previous study we reported the ROC areas of individual scores (appendicitis score for appendicitis and OB-GYN score for OB-GYNc), not as the whole algorithm like in this study. Similarly, the positive likelihood ratios for diagnosis of OB-GYNc were not significantly different in the validation data and the development data (8.73 and 12.94; P = 0.244) (Table 6). The estimate probability curves from actual rates in the development data and the validation data of appendicitis diagnosis from appendicitis score and OB-GYNc from OB-GYN score were shown (Figure 1).

4. Discussion

The present study was the second part of the previous study in clinical prediction rule for the diagnosis of acute lower abdominal pain in females of reproductive age [14]. In general, clinical prediction rule studies are comprised of derivation, validation, and impact studies, with an increase in the level of evidences in each phase [15]. Validation study is important before applying such clinical prediction rule into clinical practice because the results of prediction may not necessarily be reproducible in other settings or in the other time periods [16]. In this validation study, we found no significant differences in the prediction of diagnoses between the validation data and the development data. This could be explained simply by the fact that we conducted the study at the same setting as in the development of the diagnostic score;
Table 3: Final professional diagnosis of patients in the development data and validation data.

| Diagnoses                          | Development (n = 542) | Validation (n = 302) |
|------------------------------------|-----------------------|----------------------|
|                                    | n (%)                 | n (%)                |
| Appendicitis                       | 382 (70.5)            | 197 (65.2)           |
| OB-GYNc                            | 97 (17.9)             | 63 (20.9)            |
| Ectopic pregnancy                 | 48                    | 34                   |
| Pelvic inflammatory disease        | 7                     | 5                    |
| Complicated ovarian cyst           | 42                    | 24                   |
| NSAP                               | 63 (11.6)             | 42 (13.9)            |
| Abdominal pain without specific diagnosis | 31 | 20                   |
| Enteritis/colitis                  | 21                    | 15                   |
| Diverticulitis                     | 5                     | 4                    |
| Urinary tract infection            | 2                     | 3                    |
| Radiation enteritis                | 2                     | 2                    |
| Twisted omentum                    | 1                     |                      |

Table 4: Diagnosis suggested by the scoring system and final professional diagnosis in the validation data.

| Diagnosis suggested by scoring system | Final professional diagnosis | Total | Correct diagnosis (%) |
|--------------------------------------|-----------------------------|-------|-----------------------|
| NSAP                                 |                             | 42    | 197                   | 63        | 72.7 |
| Appendicitis                         |                             | 24    | 4                     | 5         | 33   |
| OB-GYNc                              |                             | 10    | 181                   | 12        | 203  |
| Total                                |                             | 8     | 12                    | 46        | 66   |

Table 5: Diagnostic indices (and 95% confidence interval) of the scoring system for appendicitis (versus non-appendicitis) and OB-GYNc (versus non-OB-GYNc) in the validation data (based on final professional diagnosis).

| Diagnostic indices                  | Appendicitis (versus non-appendicitis) | OB-GYNc (versus non-OB-GYNc) |
|-------------------------------------|----------------------------------------|-----------------------------|
| Sensitivity (%)                     | 91.9 (87.1–95.3)                       | 73.0 (60.3–83.4)            |
| Specificity (%)                     | 79.0 (70.0–86.4)                       | 91.6 (87.4–94.8)            |
| Receiver operating characteristic area | 0.855 (0.811–0.898)                   | 0.823 (0.765–0.881)         |
| Positive likelihood ratio           | 4.39 (3.02–6.37)                      | 8.73 (5.59–13.62)           |
| Negative likelihood ratio           | 0.10 (0.06–0.17)                      | 0.29 (0.20–0.44)            |
| Positive predictive value (%)       | 89.2 (84.1–93.1)                      | 69.7 (57.1–80.4)            |
| Negative predictive value (%)       | 83.8 (75.1–90.5)                      | 92.8 (88.7–95.7)            |

Table 6: Areas under receiver operating characteristic curves (AuROC) and positive likelihood ratios (and 95% confidence intervals) of the scoring system for appendicitis and OB-GYNc in the development and validation data.

| Diagnosis     | Development | Validation | P-value |
|---------------|-------------|------------|---------|
| Appendicitis  |             |            |         |
| AuROC         | 0.796 (0.751–0.841) | 0.855 (0.811–0.898) | 0.068   |
| Positive likelihood ratio | 2.97 (2.26–3.92) | 4.39 (3.02–6.37) | 0.100   |
| OB-GYNc       |             |            |         |
| AuROC         | 0.808 (0.750–0.865) | 0.823 (0.765–0.881) | 0.706   |
| Positive likelihood ratio | 12.94 (7.91–21.17) | 8.73 (5.59–13.62) | 0.244   |

Patients’ characteristics and patterns of clinical practices were unlikely to be different from time to time. Clinical scoring for the diagnosis of abdominal pain has been extensively studied for appendicitis [17–22]. There were relatively fewer studies for obstetrics and gynecological conditions [23–25]. However, those studied were applied for the diagnosis of only single disease (appendicitis, ectopic pregnancy, pelvic inflammatory disease, or adnexal torsion). The present diagnostic score has an advantage in inferring differential diagnosis of more than one condition, resembling...
The result of this study should be used with caution. Patients in our setting were mainly referred from smaller hospitals in Chiang Mai. Most of them needed to be admitted to either general surgery department or obstetrics and gynecology department. Different patients’ characteristics and different patient flows in other settings would affect the accuracy of the scoring system. For example, myoma uteri complications such as necrosis or torsion were rare in our settings. In other hospitals where myoma uteri complications are major causes of acute lower abdominal pain, this diagnostic score may not be suitable for such settings. Applying this scoring system to different settings, different patterns of patients flow, could probably lead to misdiagnoses in some conditions. External validation in different settings should be performed prior to adoption into clinical practice in other settings. Further impact studies of the score to assess its impacts on multidimensions of clinical practice, such as time spent in emergency department, additional diagnostic value on top of unaided junior physicians’ judgments, and time and cost of diagnosis, should be conducted in the future.

5. Conclusion

The clinical diagnostic score can triage appendicitis, OB-GYNc, and NSAP in female patients with acute lower abdominal pain. The diagnostic score can guide emergency department physicians for proper admissions and selective management.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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