



## The comparison of sensitivity and specificity of the critical care pain observation tool (CPOT) and behavioral pain scale (BPS): a scoping review

### Perbandingan sensitivitas dan spesifitas critical care pain observation tool (CPOT) and behavioral pain scale (BPS): a scoping review

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#### ABSTRACT

**Background:** Assessing pain in critically ill patients receiving mechanical ventilatory support remains a challenge in the intensive care unit. Due to mechanical ventilation and a reduced level of consciousness, the patient was unable to verbally report perceived pain. Highly sensitive pain assessment tools are critical for pain detection in critically ill patients in the intensive care unit. The Critical Care Pain Observation Tool (CPOT) and the Behavioral Pain Scale (BPS) are two pain assessment tools recommended for use in the critical care setting

**Objective:** The purpose of this study was to compare the sensitivity and specificity of CPOT and BPS in the assessment of pain in patients receiving mechanical ventilation.

**Methods:** This study was a systematic review conducted using the Scopus, PubMed, ProQuest, and ScienceDirect databases and followed established guidelines for conducting systematic reviews or scoping reviews

**Results:** CPOT was found to be more sensitive at 95% with a cut-off score >2, whereas BPS exhibited higher specificity at 91.5% with a cut-off score >6

**Conclusion:** Both CPOT and BPS demonstrate sensitivity to painful situations and are capable of detecting pain in critically ill patients.

**Keywords:** Behavioral Pain Scale, Critical care, Critical Care Pain Observation Tool, Pain assessment.

#### ABSTRAK

**Latar Belakang:** Pengkajian nyeri pada pasien kritis dengan penggunaan ventilasi mekanik masih merupakan tantangan di ruang perawatan intensif. Pasien tidak dapat melaporkan nyeri yang dirasakan secara verbal, akibat dari adanya penggunaan ventilasi mekanik dan penurunan tingkat kesadaran. Alat pengkajian nyeri yang sensitif sangat dibutuhkan untuk mendeteksi nyeri pada pasien kritis di ICU. *Critical Care Pain Observation Tools* (CPOT), dan *Behavioral Pain Scale* (BPS) merupakan dua jenis alat pengkajian nyeri yang telah direkomendasi penggunaannya di ruang kritis.

**Tujuan:** Tujuan penelitian ini untuk membandingkan sensitivitas dan spesifitas CPOT dan BPS dalam penilaian nyeri pada pasien dengan penggunaan ventilasi mekanik.

**Metode:** Penelitian ini merupakan tinjauan sistematis dengan menggunakan data base dari Scopus, PubMed, ProQuest, dan ScienceDirect serta mengikuti pedoman yang telah ditetapkan untuk melakukan penelitian dengan cara systematic reviews untuk penelitian scoping reviews.

**Hasil:** CPOT ditemukan lebih sensitif 95% dengan skor cut of point >2, sedangkan BPS ditemukan lebih spesifik 91,5% dengan skor cut of point >6.

**Kesimpulan:** CPOT dan BPS sensitif terhadap situasi yang menyakitkan, dan mampu mendeteksi adanya nyeri pada pasien kritis.

**Kata kunci:** Behavioral pain scale, Critical care pain observation tool, Pengkajian nyeri, Perawatan kritis.

## BACKGROUND

In the intensive care unit (ICU), Patients in critical condition undergo painful experiences during rest, care, and medical procedures. Therefore, one of the priorities in treating critically ill patients is to control their pain.<sup>1</sup> Unrecognized pain can cause ongoing discomfort and have numerous deleterious effects on patients, including immunosuppression and increased cardiac and respiratory stress, ultimately affecting morbidity, mortality, and the development of chronic pain.<sup>2</sup> Even though pain is prevalent among severely ill individuals, evaluating it poses a notable challenge.<sup>3</sup>

The initial and fundamental stage for successful pain management involves precisely assessing pain using suitable tools.<sup>4</sup> Assessing pain in the ICU poses challenges as patients are unable to communicate verbally,<sup>5</sup> and pain is a subjective, multidimensional concept.<sup>6</sup> The inability of ICU patients to express their pain does not mean that pain is present or that appropriate pain treatment is needed.<sup>7</sup>

Conducting a thorough evaluation of pain is crucial for effective pain treatment. Several pain assessment scales for nonverbal patients are available for use in the intensive care unit.<sup>8</sup> However, to identify pain in critically ill patients, valid, sensitive, and specific pain assessment scales are needed.<sup>2</sup> Clinical guidelines from the American Society for Pain Care Management recommend critical care specialists use the Behavioral Pain Scale

and the Critical Care Pain Observation Tool. Assessing pain in patients who cannot verbally communicate should encompass observing subjective pain-related behaviors, such as facial expressions, posture, and body movements.<sup>9</sup> The use of CPOT and BPS supports decision-making, thereby improving pain assessment.<sup>10</sup>

The Society of Critical Care Medicine recommends the use of CPOT or BPS for routine pain assessment.<sup>11</sup> However, it is unclear which of these scales is more sensitive and specific in assessing pain for patients in critical condition. Therefore, the purpose of this study was to compare the sensitivity and specificity of CPOT and BPS in the assessment of pain in patients receiving mechanical ventilatory support.

## METHODS

The procedures used in this study were developed using current guidelines for systematic review methods and scoping review research methods (PRISMA-ScR).<sup>12</sup> The literature review focused on studies of two pain assessment scales, the Critical Care Pain Observation Tool (CPOT) and the Behavioral Pain Scale (BPS). The literature search was limited to studies using CPOT and BPS to assess pain in mechanically ventilated adult patients within the past decade, covering the period 2013 to 2023. The literature search strategy for this article included Scopus, PubMed, ScienceDirect, and

ProQuest databases. The literature search employed Boolean operators "OR/AND," using the following keywords: (Pain assessment OR Pain scale OR Pain Measurements) AND (Critical care pain observation tool OR CPOT) AND (Behavioral pain scale OR BPS) AND (Critical care OR Intensive care).

Through the literature search of 4 databases, a total of 213,705 articles were

retrieved. The researchers then conducted a careful and comprehensive screening of all received articles. The screening process resulted in 11 articles that were deemed appropriate, consistent with the study objectives, and met the criteria for a systematic analysis in the form of a scoping review.

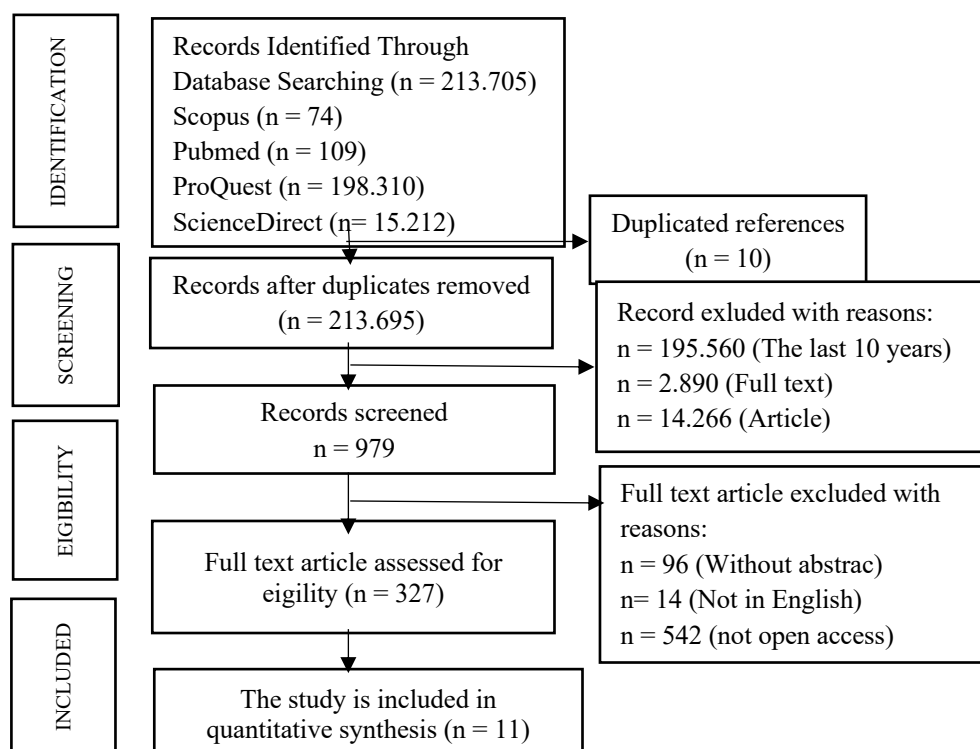


Fig. 1 PRISMA-ScR flowchart of the study selection and inclusion process

### Summary

The researchers conducted a systematic data search in December 2023 and retrieved 213,705 articles from 4 databases: 74 articles in Scopus, 109 articles in PubMed, 198,310 articles in ProQuest, and 15,212 articles in ScienceDirect article (Figure 1). First, the researchers identified and removed ten

duplicate articles. Subsequently, 212,716 articles were excluded as articles based on selection criteria over the past ten years, full-text availability, and document type. Additionally, 652 articles were excluded due to missing abstract, non-English language, and non-open access status. Subsequently, 327 full texts were individually assessed, resulting in the

selection of 11 articles deemed consistent with the study objectives.

### Study characteristics

Table 1 describes the study characteristics, starting from Author/Year/Country, Research Objectives, Study Design, Participant/Research Sample, Research Tools/Instruments, and Findings. All 11 selected articles were observational studies. The selected articles were relevant to CPOT and BPS, focusing on findings regarding sensitivity and specificity values. The following section discusses a comparison of sensitivity and specificity between critical care pain observation tools and behavioral pain scales.

## RESULTS

### 1. Sensitivity and Specificity of the Critical Care Pain Observation Tool (CPOT) and Behavioral Pain Scale (BPS)

Chinese studies using CPOT and BPS in China found that translations were made from the original CPOT and BPS. The Chinese versions of CPOT have 80.6% sensitivity and 63.6% specificity. The sensitivity Chinese version of BPS is 90% and the specificity is 45.5%.<sup>13</sup> These results differ from previous studies using the Chinese version of the BPS for pain measurement, which had a sensitivity of 52.4% and a specificity of 87.5%. The variations in this research indicate that the Chinese version of BPS may not have

reached optimal or stable use. Further studies are needed to confirm the stability and accuracy of its sensitivity and specificity.

A comparative study of CPOT and BPS conducted in Italy showed that the sensitivity of BPS was 62.8% and the specificity was 91.7%. Meanwhile, CPOT showed 76.5% sensitivity and 70.8% specificity.<sup>14</sup> BPS exhibited elevated specificity yet reduced sensitivity in contrast to CPOT, which displayed increased sensitivity but reduced specificity. These results indicate that CPOT cannot be unequivocally declared superior to BPS or vice versa. The use of CPOT and BPS, respectively, has shown good utility in detecting pain behavior in patients during care. However, the combination of BPS and CPOT resulted in 80.4% sensitivity, 75% specificity. This suggests that the combined use of BPS and CPOT during nursing care or other pain interventions may enhance pain assessment.<sup>14</sup>

CPOT and BPS scores increased during the ICU implementation care and their outcomes were significantly correlated. Although both scales can assess pain intensity, BPS was found to have higher specificity (91.7%) than CPOT (70.8%) but lower sensitivity (62.7%) than CPOT (76.5%).<sup>15</sup> These results suggest that most patients experience pain during routine care in the ICU. Both BPS and CPOT are effective tools for detecting pain through changes in patient behavior and

provide information about pain in ventilated patients. These results differ from the study by Klein et al. which states that CPOT is more specific than BPS.<sup>16</sup> Multiple studies have concluded that both CPOT<sup>16</sup> and BPS<sup>17</sup> are reliable, valid, sensitive, and specific in pain assessment in patients in critical condition receiving mechanically ventilated.<sup>15</sup>

Pain assessment during routine ICU surgery showed CPOT has 93% sensitivity, and 84% specificity.<sup>18</sup> Different studies have used different pain stimuli to validate CPOT. CPOT's high sensitivity demonstrates its ability to detect patient pain and differentiate between treatment procedures that cause discomfort and those that do not.

The validity of Portuguese versions of CPOT was tested using the Behavioral Pain Scale (BPS) as a comparison. Assessments were performed during and 20 minutes after nursing procedures such as patient repositioning and endotracheal suctioning. Results showed that the Portuguese versions of CPOT had 71% sensitivity and 80% specificity.<sup>19</sup> Similar results were found when testing the effectiveness of the Swedish version of the BPS, which had 88% sensitivity and 58% specificity.<sup>20</sup> CPOT and BPS can be used in non-verbal ICU patients on mechanical ventilation.

The survey of the psychometric properties of CPOT revealed 84% sensitivity and 69% specificity. However,

when the overall sample in this study was separated according to the RASS score, the sensitivity and specificity of CPOT changed. Group 1; RASS scores of -3 to -1, representing sedated patients, had a CPOT sensitivity of 70% and specificity of 83%. Group 2; RASS score +1 indicates the patient is agitated, with CPOT sensitivity of 95% and specificity of 87%. Group 3 had a sensitivity of 69% and a specificity of 66%. The differences in sensitivity and specificity results in this study were affected by multiple factors, such as different sample sizes and different limit determinations.<sup>8</sup>

A validation study of CPOT, BPS, and NVPS showed that researchers did not measure sensitivity and specificity values for these three tools. That's because, according to the researchers, these three instruments are sensitive and specific at detecting pain and, importantly, are the ones most often recommended use for critically ill patients in critical care units.<sup>21</sup>

## **2. Cut of point**

The cutoff value is the value that distinguishes normal from abnormal or painful from non-painful test results.<sup>22</sup> The score for the line Chinese version of BPS is >6, and the score line Chinese version of CPOT is >3.<sup>13</sup> These values are consistent with previous CPOT studies conducted in the UK. However, in previous studies, CPOT had different optimal cutoff values, such as >2. Differences in CPOT cutoff score determination may influence why



patients are treated in the ICU. The English versions of CPOT and BPS set the BPS limit to  $>5$  and the CPOT limit to  $>2$ .<sup>13</sup> These results are consistent with Society of Critical Care Medicine guidelines. The original CPOT owner set the limit to  $>3$ , but studies have also used different CPOT limits, such as  $>2$ .<sup>18</sup> A cutoff score  $>2$  was also used to validate CPOT in the Portuguese version, using BPS as the comparator.<sup>19</sup> When validating the Polish version of CPOT, the CPOT limit  $>2$  also applies.<sup>23</sup> German CPOT was validated using different cutoffs:  $\geq 3$  for nurses and  $\geq 2$  for physicians. Differences in these cutoff scores can be adjusted based on the patient's state.<sup>24</sup>

The determination of cutoff scores in individual studies may vary based on study objectives and patient status. In her study, Chookalayia initially set a cap of 1.5 for all respondents. However, across the entire sample, they divided respondents into three groups. This classification is based on the assessment of the patient's level of consciousness using the RASS score. Group 1 represents samples from the calm category, Group 2 represents samples from the agitation category, and Group 3 represents samples from the highly agitated category. This classification is also based on awareness assessment using the RASS score. The limit is set to 4.5, especially for severely disturbed patients.<sup>8</sup>

### 3. Area Under the Curve (AUC)

The Chinese version of CPOT showed better pain detection ability with an AUC (Area Under the Curve) value of 76.4% compared with BPS with an AUC of 73.1%.<sup>13</sup> Although this difference was not statistically significant, the Chinese version of CPOT appears to assess patients' pain behavior more frequently or more effectively than the BPS. The ROC curve during care showed an AUC of 0.84 for using both BPS and CPOT together. Using both BPS and CPOT together can be considered a good tool for pain assessment in patients in critical condition with mechanically ventilated.<sup>14</sup>

In a validation study comparing the Portuguese version of CPOT with BPS, pain was evaluated while performing care procedures like patient transfers and endotracheal suctioning, and 20 minutes after the care procedure. The study produced ROC results with AUC values ranging from 0.6 to 0.8. These values indicate that the Portuguese version of CPOT performs well in detecting pain in patients. Area Under the Curve (AUC) values measured while providing care were found to be higher.<sup>19</sup>

## DISCUSSION

CPOT showed a range of sensitivity values, from a low of 69% to a high of 95%.<sup>8</sup> These values indicate that CPOT has relatively high to maximum sensitivity in detecting pain in patients in critical condition receiving mechanical ventilation. The lowest CPOT specificity

value recorded was 63.6%,<sup>13</sup> and the highest was 87%.<sup>8</sup> These values indicate that CPOT has relatively high to high specificity in detecting pain freedom in patients in critical condition receiving mechanical ventilation. The implementation of nursing measures resulted in higher CPOT sensitivity values. This also supports the idea that nursing interventions contribute to pain in patients in critical condition treated in intensive care units. The difference in CPOT sensitivity results between 69% and 95% may also be affected by the time of measurement. Valid time frames for measuring patient pain include assessments during rest, pre-care measures, during-care measures, and post-care measures.

The Behavioral Pain Scale (BPS) showed sensitivity ranging from a lowest value of 45.5%<sup>9</sup> to a highest value of 91.7%.<sup>14</sup> The specificity of the Chinese version of the BPS was 45.5%, which is different from the 87.5% specificity value of the Chinese version of the BPS reported in previous studies.<sup>13</sup> Variation in the specificity values obtained by BPS is affected by the determination of the cutoff score and examination sample size. Compared with previous studies, the specificity value of the Chinese version of BPS was 45.5% with a smaller sample size. The inconsistency between the results of these two studies on the Chinese version of the BPS scale suggests the instability of its use in different populations,

and further research is needed to clarify the optimal use of the Chinese version of the BPS scale.

In two studies included in this review, sensitivity and specificity values for CPOT and BPS were not reported numerically. However, they agreed with previous studies on CPOT and BPS and concluded that both BPS and CPOT are pain scales with high sensitivity and specificity. They recommend using these scales to assess pain in critically ill patients.<sup>23,21</sup>

Differences in sensitivity and specificity values of CPOT and BPS may be affected by the chosen cutoff score. Hoda Chookalayia et al. In their study, the CPOT cutoff was set at 1.5 for sedated patients and 4.5 for agitated patients, which resulted in different sensitivity and specificity values.<sup>8</sup> The original CPOT authors established an optimal cutoff score of >3.<sup>18</sup> However, an optimal cutoff score of >2 has been used in several studies.<sup>18,19,23</sup> Similar variability exists in determining cutoff values for BPS. To examine the association between BPS and CPOT scores in critically ill patients, a cutoff score of >5 was used.<sup>25</sup> An optimal cutoff score of >6 has now been determined in the validation of the Chinese BPS. The setting of specific limits can be adjusted based on the patient's level of consciousness.<sup>16</sup> The selection of the optimal cutoff value has a significant impact on the final sensitivity

and specificity results of CPOT and BPS diagnostic tests.

Diagnostic testing for CPOT and BPD often uses receiver operating curve (ROC) analysis as a statistical method. ROC is a method of determining the cutoff value of a diagnostic test by graphically representing the trade-off between sensitivity and specificity. The area under the curve values (AUC) for CPOT and BPS indicate the ability of both instruments to differentiate between patients with pain and those without pain. The higher or larger the curve is toward the upper left corner, the higher the sensitivity achieved. On the contrary, the closer the curve is to the diagonal, the lower the sensitivity obtained. In a study combining CPOT and BPS, Severgnini et al. The AUC value was 0.84. The AUC value of the BPS and CPOT combination was 0.84, indicating that the combination of these two tools produced good results in detecting behavior and pain in mechanically ventilated patients.<sup>14</sup>

## CONCLUSION

This study concluded that the sensitivity and specificity values of diagnostic tests for CPOT and BPD are conflicting. This means that the higher the sensitivity value obtained, the lower the specificity value and vice versa. CPOT was found to be more sensitive than BPS. CPOT showed higher sensitivity, up to 95%, while BPS had higher specificity, up to 91.5% specificity value. Both CPOT and BPS are sensitive to painful conditions and

are capable of detecting pain in patients through behavioral assessment of mechanically ventilated critically ill patients.

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Table 1. The review of article

Author/ Year/Cou ntry	Objective	Study design	Particip ant	Tools	Result
<b>Katarzyn a Kotfis et.al. 2018, Polandia. 23</b>	To validate cpot translated into Polish	Prospec tive observat ional cohort study	71 patiensi ICU with ventilato rs	CPOT versi Polandi a	The device has a sensitivity and specificity of 0.978 to 0.974, with an optimal cutoff point of >2 for the treatment of sinusitis. The AUC value was 0.978 to 0.974, the AUC value was 0.950 to 0.926 and 0.926 AUC ama prosedur nosiseptif adalah 0.938 dan 0.951.
<b>Shiva Gomarve rdi et.al. 2019, Iran.<sup>15</sup></b>	Comparing patients with pain scale BPS and CPOT during the routine procedure in icu	Cross- sectiona l study	90 patiensi ICU with ventilato rs	BPS, dan CPOT	BPS specificity (91.7%), CPOT (70.8%), and high sensitivity (BPS 62.7%, CPOT 76.5%). The sensitivity of the combination of BPS and CPOT reaches 80.4%.
<b>Hoda Chookala yi et.al 2018, Iran.<sup>8</sup></b>	To evaluate the psychometry cpot	cross- sectiona l study	65 patiensi ICU with ventilato rs	CPOT	The CPOT sensitivity is 84% and the CPOT specificity is 69%. Skor starts at 1.5 points with a popular sampling sensitivity of 84% and a specific sensitivity of 69%. The Skor part of point 1.5 has higher sensitivity, which are 70% sensitivity, 83% sensitivity, 95% sensitivity and 87% sensitivity respectively. Skor cutoff point 4.5 has a sensitivity of 69% and a specification of 66%.
<b>Yumi Ito et.al. 2022, Japan.<sup>25</sup></b>	Investigates the relations score CPOT and BPS in critical patients	Studi observa sional retrospe ktif	34 patiensi ICU with ventilato rs	CPOT, dan BPS	Skor Cut of point CPOT reaches >5 and BPS>2. CPOT needs to increase the sensitivity level of its equipment.
<b>Li-Hua cheng et.al. 2018, Taiwan.<sup>9</sup></b>	Validation CPOT and BPS speak Chinese as a measure pain critical patients	Crossov er, observat ional study	316 patiensi ICU with ventilato rs	CPOT, dan BPS versi China	Skor Cut of point CPOT is 3; sensitivity 80.6%, specificity 63.6%, AUC 76.4%. For the Chinese BPS version, score >6; sensitivity 90.0%, specificity 45.5%, AUC 73.1%.
<b>Sanna- Let et.al. 2018, Finland.<sup>21</sup></b>	To test the reliability of three pain assessment devices translated into Finland for use in intense patients with ventilators	Studies observat ional	6 patiensi ICU with ventilato rs	BPS, CPOT, dan NVPS	CPOT, BPS, and NVPS were processed through sensitivity and specificity and showed that they most widely recommendation
<b>Mia Hylen et.al. 2019, Sweden.<sup>20</sup></b>	Develops the domain's breathing pattern on the Swedish	Studies observat ional,	59 patiensi ICU with and without	BPS, BPS-NI, NRS	BPS has a Swedish sensitivity of 88% and a sensitivity of 58%.

	version of pain scale	Study	ventilators		
<b>Kiesewetter, I et al. 2019, German.<sup>24</sup></b>	Establish the validity of reliability and cpot in Germany for the critical adult	Studi validasi prospektif observasional	292 Patients post op heart surgeon	CPOT	Skor cut of point $\geq 3$ , AUC 0.59, sensitivity 29.09, specificity 91.28. The cutoff point for this value was $\geq 2$ , the AUC was 0.55, the sensitivity was 36.61, and the specificity was 82.24.
<b>Rita Marques et al. 2022, Portugal.<sup>19</sup></b>	Validation CPOT in Portugal critical adult patients	Studi kohort observasional prospektif	110 patients ICU with ventilators	CPOT dan BPS	Skor Cut of CPOT points, optimal value $>2$ at sensitivity 71% and specification 80%
<b>Emsden, C et al. 2019, Swiss.<sup>18</sup></b>	To test cpot in germany in patients adult heterogeneo us in icu	Studi observasional	91 patients ICU with ventilators	CPOT dan BPS	Skor cut of point CPOT $>2$ . When the classification AUC was 0.97, the classification AUC was 0.98, the sensitivity was 93%, and the specification was 84%.
<b>Severgnini, P et al. 2016, Italia.<sup>14</sup></b>	Compare CPOT and BPS on a patient conscious and unconscious	Studi observasional	101 patients ICU with ventilators	CPOT dan BPS	The average sensitivity of BPS was 62.8%, the specific sensitivity was 91.7%, and the temperature was 72.04%. CPOT sensitivity is 76.5%, specification is 70.8%, and temperature is 74.68%. The CPOT and BPS combination had a sensitivity of 80.4%, a specificity of 75%, temperature of 78.67%, and an AUC of 0.84