

Type of the Paper (Article)

## Effect of SPI Value on Predicting Post-operative Pain: A Meta-analysis

Mohamed Ahmed Hamed<sup>1</sup>, Abeer Shaban Goda<sup>1</sup>, Maha A. Mohamed<sup>1\*</sup>, Mahdy Ahmed Abdelhady<sup>1</sup>

<sup>1</sup> Anesthesia Department, Faculty of Medicine, Fayoum University, Fayoum, 63511, Egypt.

\*Correspondence: Maha A. Mohamed, [mam56@fayoum.edu.eg](mailto:mam56@fayoum.edu.eg), Tel: (002) 01061853735.

### Abstract

**Introduction:** Despite the advancement in anesthetic techniques, postoperative pain is still a significant concern in medical care. The level of pain experienced by patients undergoing the same procedure can vary. We know the potential benefits of SPI-guided anesthesia.

**Aim of the study:** To evaluate the optimum timing for measurement of SPI to be able to predict postoperative pain.

**Subjects and methods:** This meta-analysis follows the PRISMA flow diagram. This study aims to establish when intraoperative SPI should be measured to better predict postoperative pain.

**Results:** The search yielded two studies. Results of the meta-analysis show that SPI timings are significantly lower in sensitivity in the SPI five minutes after the incision as well as SPI ten minutes before the recovery ( $P < 0.001$ ). According to the NRS pain scale (numeric rating scale), 15 Min NRS showed significantly higher results than the 5 Min NRS ( $P = 0.003$ ). There was no significant change in the number of patients who had nausea ( $P = 0.99$ ).

**Conclusion:** SPI is a good indicator for nociception. SPI timings are significantly lower in sensitivity in the SPI 5 mins after the incision as well as SPI 10 minutes before the recovery.

**Key words:** SPI; The Surgical Pleth Index (SPI); Postoperative pain.

## 1. Introduction

The Surgical Pleth Index (SPI) is a dimensionless score calculated using

photoplethysmographic measurement of the pulse wave and heartbeat interval [1].

Surgery-related SPI scores may represent a patient's autonomic reaction to nociceptive stimuli [2]. It is a valuable tool for guiding intraoperative analgesia and reducing opioid consumption. Several studies have shown its use in predicting postoperative pain in both adults and children [3] and in assessing the effects of tracheal intubation and skin incision on hemodynamic response to nerve block [4, 5].

The most sensitive cut-off value since the development of SPI has a good correlation with postoperative pain intensity and the timing of SPI measurement. Has been a topic of discussion. 30 was mentioned in recent studies as the SPI cut-off point [1]. A more recent study discovered a strong correlation between opioid use and postoperative pain and SPI

response to surgical incisions [6]. Based on these findings, we speculated that they both related to postoperative pain.

The SPI is a more reliable indicator of the balance between pain and anesthesia compared to heart rate and blood pressure. SPI values range from 0 to 100, with higher values indicating greater surgical stress [7]. Using SPI as a guide for anesthesia can help determine the amount of pain relief needed and reduce the use of opioids both before and after surgery [8].

Since much research produced noticeably varied outcomes, the final cut-off value for the SPI has not yet been confirmed. In this study, we aim to evaluate the optimum timing for measurement of SPI to be able to predict postoperative pain.

## 2. Subjects and methods

### 2.1. Study design

This meta-analysis follows the PRISMA flow diagram and the guidelines of the Cochrane Handbook.

#### *Eligibility Criteria*

We included studies with the following criteria:

- Clinical Trials (Both randomized and non-randomized).
- The Age: 18 to 65 years.

#### *Exclusion criteria*

- Patients who are pregnant or breastfeeding

- Patients with dysrhythmias, such as AF or an atrioventricular block of more than the first degree.
- Pacemaker users, vasoactive therapy, any intraoperative use of clonidine, beta-receptor agonists or antagonists.
- Patients who had undergone neuraxial anesthesia were also disqualified.

## ***2.2.Primary Outcome of interest: SPI scores***

### ***Information Sources***

Up to April 2021, we looked through the databases in PubMed, Scopus, Web of Science, and Cochrane CENTRAL for papers that met our inclusion criteria.

### ***Search and Study Selection***

The included articles were reviewed in three stages. The initial stage involved utilizing EndNote Software to import the findings from electronic databases onto a Microsoft Excel sheet [9]. The second step involved two independent authors assessing the article titles and abstracts that were entered into the Excel sheet. The included citations from Step 2 were subjected to full-text screening in the third stage. In addition, we manually checked the included publications' references for any potential overlooked investigations.

### ***Data Collection***

We gathered information on A) the participants' initial demographics. B) The SPI was measured five minutes after the incision and ten minutes before recovery as outcome endpoints. C) Information for assessing the risk of bias was included in the third category. Data gathering was carried out using Microsoft Excel.

### ***Risk of Bias Assessment***

Using Cochrane's risk of bias methodology for clinical trials, two writers evaluated the risk of bias among the included papers [9]. Through seven domains, the instrument evaluates patient randomization, allocation concealment, and sufficient blinding [9]. Each domain is assigned a risk of bias rating of "low," "unclear," or "high."

### ***2.3.Analysis***

With the use of Review Manager Software, we conducted the meta-analysis for this study. Both continuous and binary outcomes were included in our study. We used mean difference (MD) and 95% confidence interval (CI) to analyze continuous data and risk ratio (RR) and 95% CI to evaluate dichotomous data. When data were homogenous, the fixed-effects model

was employed; when data were heterogeneous, the random-effects model was utilized. We used the I2 and p-value of the Chi-square tests to assess the degree of consistency between the studies [10]. The

presence of heterogeneity was significantly indicated by P-values of 0.1 or I2 > 50%. Utilizing Cochrane's leave-one-out technique, we attempted to resolve the inconsistent results of varied outcomes [10].

### 3. Results

The following is a PRISMA flow chart for our literature search

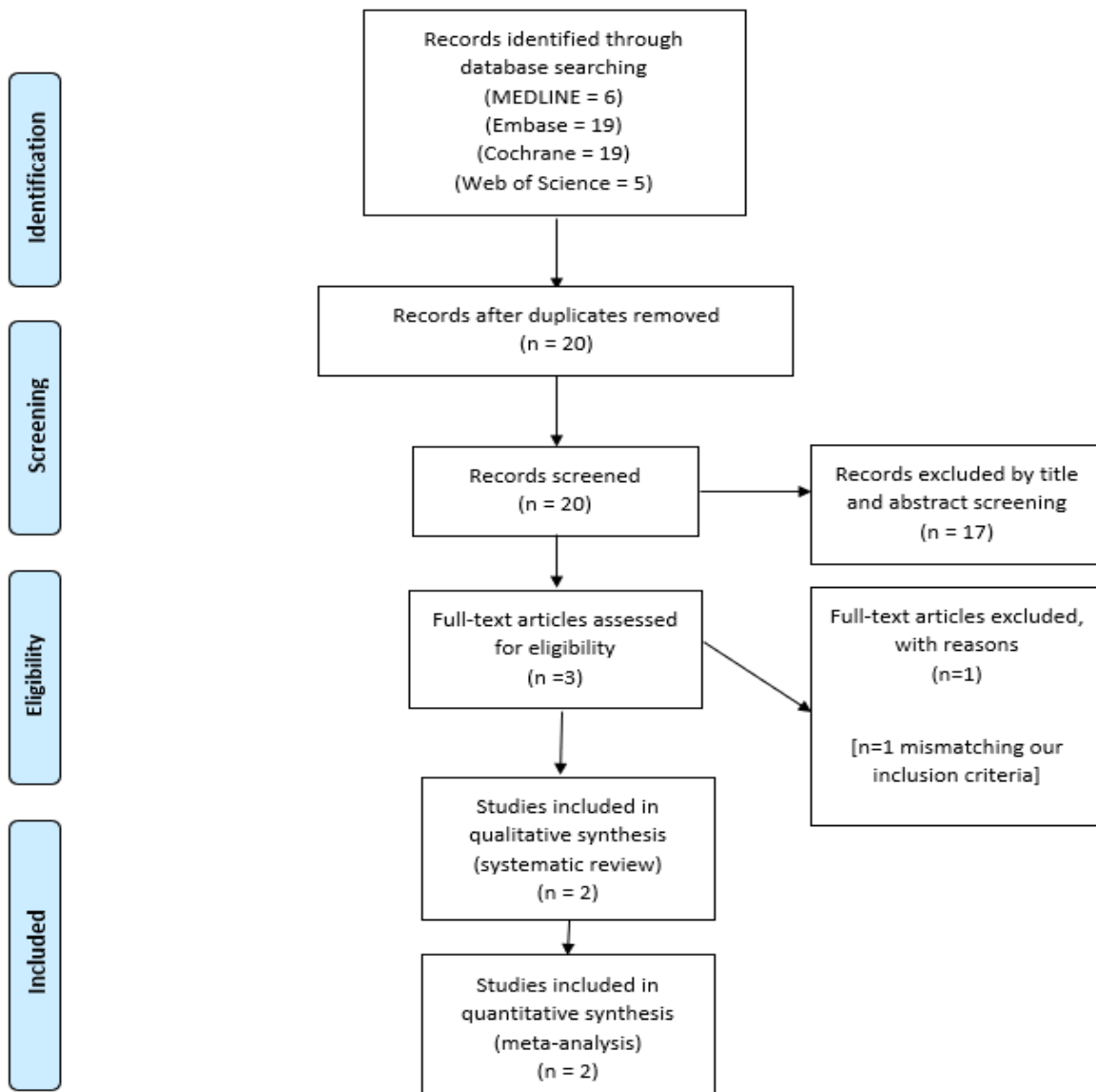


Figure 1: PRISMA flow diagram.

Results of the meta-analysis show that SPI timings are significantly lower in sensitivity in the SPI 5 mins after the incision as well as SPI 10 minutes before the recovery ( $P < 0.001$ ) (Figure 2A). According to the NRS pain scale (numeric rating scale),

15 Min NRS showed significant results ( $P = 0.003$ ), as shown in (Figure 2B). There was no significant change in the number of patients who had nausea in the ( $P = 1$ ), as shown in (Figure 2C).

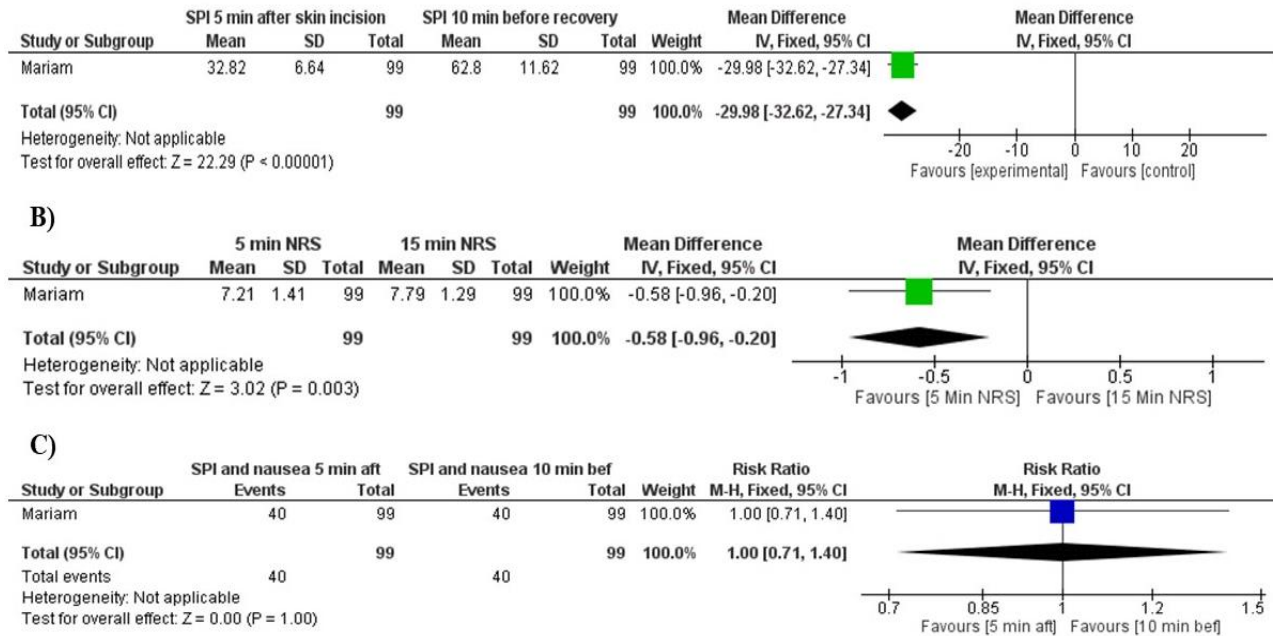


Figure 2: Results of SPI timing analysis. A) after incision and before recovery; B) NRS pain scale; C) nausea.

### 4. Discussion

Many researchers have studied the SPI scores as a monitor for patient autonomic response to surgical stimulation, the association between SPI and postoperative pain intensity, the use of SPI as an intraoperative guide for anti-nociception management, the SPI cut-off value that could differentiate between moderate and severe pain and measurement timing. The findings, meanwhile, lacked some consistency [11, 12].

SPI following skin incision and postoperative pain were found to be significantly

correlated by Jung et al. (2020), with SPI > 50 being linked to worse pain intensity and opioid use. They also identified SPI 23 as the optimal cut-off predictive value. On the other hand, our research found the opposite [6].

Ledowskiet al. (2019) found a substantial correlation between SPI before arousal and postoperative pain levels, which is consistent with our findings [1]. Nevertheless, they did note that an SPI cut-off value of 30 had rather poor sensitivity and specificity for predicting moderate-to-severe pain. In that

study, SPI and postoperative pain levels did not significantly correlate with one another. The relatively limited number of patients who participated was blamed for this outcome (only 65).

Ledowskiet et al. (2017) identified an SPI cut-off value of 40 in children as a predictor of moderate-to-severe pain in another clinical research [3]. It is important to remember that children and adults may have distinct circulatory architecture and functioning, which might result in children having lower SPI values at the same level of nociception [13]. This might account for Ledowskiet et al. (2017)'s discovery of a lower SPI cut-off value than ours [3]. The ideal SPI range that results in the best nociception-anti-nociception balance, with a general role of SPI of 20–50, is one of the key issues with this conflict [14]. This, however, is outside the purview of the present investigation.

In contrast to SPI 5 minutes after the skin incision, we discovered a correlation between SPI 10 minutes before recovery and postoperative nausea in our study. This is explained by the association between SPI 10 and opioid use that we discovered. Opioids are linked to several negative side effects, such as

## Conclusion

The assessment of nociception can be facilitated by utilizing the SPI score. SPI is a good indicator for nociception. SPI timings are

**Funding:** This research is not funded.

## References

1. Ledowski T, Schneider M, Gruenewald M, Goyal RK, Teo SR, Hruby J. Surgical pleth index: prospective validation of the score to predict moderate-to-severe postoperative pain. *Br J Anaesth.* 2019;123(2):e328-e332. doi: 10.1016/j.bja.2018.10.066.
2. Ledowski T. Objective monitoring of

respiratory depression, drowsiness, nausea, vomiting, and constipation [15]. We did not discover any other negative impacts, though.

The study has a few drawbacks. Initially, instead of trending, they just compared two SPI readings. Moreover, the SPI 5 measurement may be impacted by the administration of analgesics during induction. Second, they did not examine how patient factors, such as age, which was known to impact SPI score, affected the measures of the SPI [13]. Finally, comparisons of their data were constrained by the paucity of comparable investigations. That study was the first to compare the two metrics, as far as we are aware. Furthermore, the fact that their study was conducted at a single center may have limited the generalizability of their findings. Despite these drawbacks, their investigation can support the link between SPI readings and pain ratings. Also, it said that there is a stronger correlation between pre-arousal SPI and opioid usage and postoperative pain ratings. The inclusion of one study remains one of the major limitations of our study. However, the literature search process did not reveal any study similar to ours.

significantly lower in sensitivity in the SPI 5 mins after the incision as well as SPI 10 minutes before the recovery.

**Conflicts of Interest:** All authors declare no conflict of interest.

3. Ledowski T, Sommerfield D, Slevin L, Conrad J, von Ungern-Sternberg BS. Surgical pleth index: prediction of postoperative pain in children? *Br J Anaesth.* 2017;119(5):979-983.

- doi: 10.1093/bja/aex300.
4. Wang M, Wang X, Bao R, Zhu WZ, Bian JJ, Deng XM, Han WJ, Wang JF. Predictive value of the surgical pleth index for the hemodynamic responses to trachea intubation and skin incision. *J Clin Monit Comput.* 2020;34(6):1303-1309. doi: 10.1007/s10877-019-00425-6.
  5. Choi JJ, Jo YY, Kim SH, Jung WS, Lee D, Kim KY, Kwak HJ. Remifentanil-Sparing Effect of Pectoral Nerve Block Type II in Breast Surgery under Surgical Pleth Index-Guided Analgesia during Total Intravenous Anesthesia. *J Clin Med.* 2019;8(8):1181. doi: 10.3390/jcm8081181.
  6. Jung K, Park MH, Kim DK, Kim BJ. Prediction of Postoperative Pain and Opioid Consumption Using Intraoperative Surgical Pleth Index After Surgical Incision: An Observational Study. *J Pain Res.* 2020;13:2815-2824. doi: 10.2147/JPR.S264101.
  7. Constant I, Sabourdin N. Monitoring depth of anesthesia: from consciousness to nociception. A window on subcortical brain activity. *Paediatr Anaesth.* 2015;25(1):73-82. doi: 10.1111/pan.12586.
  8. Jiao Y, He B, Tong X, Xia R, Zhang C, Shi X. Intraoperative monitoring of nociception for opioid administration: a meta-analysis of randomized controlled trials. *Minerva Anesthesiol.* 2019;85(5):522-530. doi: 10.23736/S0375-9393.19.13151-3.
  9. Green S HPJT, Alderson P, Clarke M, Mulrow D C, Oxman D A. . *Cochrane Handbook: Cochrane Reviews: Ch 8: Assessing risk of bias in included studies.* In: *Cochrane Handbook for: Systematic Reviews of Interventions.* 2011:3-10.
  10. Higgins JPT GSCHfSRoI, p. CBSVV. *Cochrane Handbook for Systematic Reviews of Interventions: Cochrane Book Series.* 2008.
  11. Ledowski T, Burke J, Hruba J. Surgical pleth index: prediction of postoperative pain and influence of arousal. *Br J Anaesth.* 2016;117(3):371-4. doi: 10.1093/bja/aew226.
  12. Le Gall L, David A, Carles P, Leuillet S, Chastel B, Fleureau C, Dewitte A, Ouattara A. Benefits of intraoperative analgesia guided by the Analgesia Nociception Index (ANI) in bariatric surgery: An unmatched case-control study. *Anaesth Crit Care Pain Med.* 2019;38(1):35-39. doi: 10.1016/j.accpm.2017.09.004.
  13. Park JH, Lim BG, Kim H, Lee IO, Kong MH, Kim NS. Comparison of Surgical Pleth Index-guided Analgesia with Conventional Analgesia Practices in Children: A Randomized Controlled Trial. *Anesthesiology.* 2015;122(6):1280-1287. doi: 10.1097/ALN.0000000000000650.
  14. Struys MM, Vanpeteghem C, Huiku M, Uutela K, Blyaert NB, Mortier EP. Changes in a surgical stress index in response to standardized pain stimuli during propofol-remifentanil infusion. *Br J Anaesth.* 2007;99(3):359-367. doi: 10.1093/bja/aem173.
  15. Baca Q, Marti F, Poblete B, Gaudilliere B, Aghaeepour N, Angst MS. Predicting Acute Pain After Surgery: A Multivariate Analysis. *Ann Surg.* 2021;273(2):289-298. doi: 10.1097/SLA.0000000000003400.