Preoperative Renal Artery Embolization Before Radical Nephrectomy for Nonmetastatic Renal Cell Carcinoma: A Propensity Score Matched Analysis

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Purpose: This study investigated the effects of preoperative renal artery embolization (PRAE) before radical nephrectomy (RN) for advanced nonmetastatic renal cell carcinoma (RCC) on perioperative and oncologic outcomes.

Materials and Methods: We analyzed 820 patients who had undergone RN for advanced nonmetastatic RCC (cT3-4/N0-1) between June 2003 and May 2022. Propensity score matching (PSM) at a 1:2 ratio was performed using the nearest-neighbor method, matching 121 PRAE patients to 242 controls. The primary endpoints included recurrence rate, overall survival, cancer-specific survival, and recurrence-free survival.

Results: Before PSM, there were differences in sex (p=0.047), clinical stage (p=0.001), and the Fuhrman grade (p<0.001) between the 2 groups. After PSM, the baseline characteristics were well balanced. The mean age at operation was 58.2±13.0 years, and the median follow-up was 42.0 months. The postoperative transfusion rate was higher in PRAE group (18.2% vs. 10.7%, p=0.049). No significant differences were found between the PRAE and control groups in operation time (166.6±95.3 minutes vs. 155.5±74.2 minutes, p=0.263), estimated blood loss (360.4±732.0 mL vs. 293.4±596.6 mL, p=0.384), or length of hospital stay (7.7±4.9 days vs. 7.7±3.7 days, p=0.961) between the 2 groups. Recurrence was significantly less common in the PRAE group than in the control group (20.7% vs. 34.3%, p=0.007). No significant differences were found in cancer-specific death (8.3% vs. 9.1%, p=0.793) or overall death (8.3% vs. 12.0%, p=0.281). In multivariate logistic regression analysis, clinical T stage ≥3 (odds ratio [OR], 4.365; p<0.001), clinical N stage 1 (OR, 2.405; p=0.020) and no PRAE (OR, 2.293; p=0.004) were independent predictors of recurrence.

Conclusions: Our results showed that PRAE was related to a lower recurrence rate. Thus, PRAE seems to be useful before RN for nonmetastatic RCC patients.

Key Words: Renal cell carcinoma, Nephrectomy

INTRODUCTION

Renal cell carcinoma (RCC) is the most frequent type of renal malignancy, accounting for 2.4% of all adult cancers in South Korea [1]. Surgical resection is currently acknowledged as the standard treatment for localized RCC [2,3]. The most recent guidelines from the European Association of Urology (EAU) [4] recommend partial nephrectomy (PN) for clinical T1 stage RCC. For advanced localized RCC, radical nephrectomy (RN) is the preferred treatment. PN may also...
be an option for T2–3a RCC, but the risks and benefits must be carefully weighed. Since cytoreductive nephrectomy can offer oncologic benefits for patients with metastatic RCC [5,6], the clinical significance of RN in treating advanced RCC is substantial.

Percutaneous renal arterial embolization (RAE) was first introduced into clinical practice in the 1970s [7]. Initially, its applications were confined to treating symptomatic hematuria and providing palliation for metastatic RCC. Over time, the indications for RAE have expanded to include a variety of conditions such as persistent bleeding, hemorrhagic angiomyolipoma, arteriovenous fistulae, and vascular malformations [8,9]. Furthermore, performing RAE prior to PN in RCC patients has been shown to reduce blood loss during surgery [10]. At present, RAE is recognized as a safe procedure with few complications, the majority of which are postinfarction syndromes such as pain, fever, nausea, and vomiting [8].

In advanced RCC cases, preoperative renal artery embolization (PRAE) has begun to be implemented prior to RN to induce preoperative infarction, thereby facilitating tumor resection with less blood loss compared to RN alone [11,12]. Numerous retrospective series that have evaluated the use of PRAE before surgical resection have reported reductions in intraoperative blood loss, operation time, and involvement of adjacent organs, thus enabling a more comprehensive resection [13,14]. It is generally recommended to perform PRAE less than 48 hours before RN to minimize the distress caused by postinfarction syndrome [15]. In terms of oncologic outcomes, some studies have reported that PRAE does not improve the prognosis following surgery [16]. Conversely, other studies have suggested that PRAE results in a better prognosis after RN than RN alone [17,18]. These improvements in survival may be due to immunotherapeutic responses, including lymphoproliferative responses and the enhancement of natural killer cell activity, which follow tumor necrosis after PRAE [15,19,20]. However, all these previously published studies were non-randomized and had a selection bias. Therefore, the true role of PRAE remains undetermined [21].

Thus, the objective of this study was to assess the effects of PRAE for nonmetastatic RCC before RN on perioperative and oncologic outcomes.

MATERIALS AND METHODS

We conducted a retrospective analysis of data from patients who underwent RN for nonmetastatic RCC. This took place at a single tertiary center between June 2003 and May 2022. This study was approved by the Institutional Review Board (IRB) of Seoul National University Bundang Hospital (IRB No. B-2212-801-107).

Patients aged over 20 years, with nonmetastatic RCC staged as clinically T1-T4/N0-N1, who had undergone RN were included in this study. All patients were definitively diagnosed with RCC via a pathological report following RN. We excluded patients with bilateral synchronous tumors, von Hippel-Lindau syndrome, or histology inconsistent with RCC. The procedures performed included open RN, hand-assisted laparoscopic RN, laparoscopic RN, and robot-assisted laparoscopic RN. Tumor size was determined by the longest diameter of the tumor, as measured by preoperative computed tomography (CT) scan or magnetic resonance imaging (MRI). The renal nephrometry score [22], based on CT or MRI, was used to evaluate the anatomical features and complexity of the tumors.

There were no standardized guidelines for conducting PRAE. Surgeons individually determined the necessity of PRAE in patients who were considered surgically challenging or who had aggressive forms of cancer. Various anatomical features identified in the images, including complex vasculature with multiple feeding vessels, potential adhesions surrounding the tumor, or exceptionally large tumors, were viewed as challenging surgical conditions or indicative of an aggressive tumor.

Radiologists at the center performed PRAE within 24 hours prior to surgery to mitigate postinfarction symptoms such as pain, fever, nausea, vomiting, and the like. Arteriography was conducted via a common femoral artery puncture to visualize the ipsilateral renal arterial structure and hypervascular tumor staining. Following the identification of the vascular anatomy, PRAE was carried out using a polyvinyl alcohol particle, Gelfoam, and a detachable coil. If complete occlusion of the target vessel was confirmed, PRAE was deemed technically successful [23].

In this retrospective study, propensity score matching (PSM) was utilized to minimize the selection bias of potential...
confounders. Prior to implementing PSM, significant differences were observed in baseline characteristics such as sex (p=0.047), clinical stage (p=0.001), and Fuhrman grade (p<0.001) among the 830 patients included in the study. We applied 1:2 PSM using the nearest-neighbor method, taking into account variables such as age, sex, body mass index, diabetes, hypertension, chronic kidney disease performance status, clinical stage, and pathologic reports. As a result, we successfully matched 121 patients with PRAE to 242 control patients.

The primary endpoints of our study were oncologic outcomes, which included the recurrence rate, overall survival (OS), cancer-specific survival (CSS), and recurrence-free survival (RFS). Local recurrence, recurrence at ipsilateral regional structures (such as retroperitoneal lymph nodes and the psoas muscle), and distant recurrence were included. The secondary endpoints were perioperative and postoperative outcomes, which included operation time, estimated blood loss during surgery, the number of patients who required postoperative transfusion, the volume of transfusion (pack), and the length of hospital stay.

The baseline characteristics were analyzed using descriptive statistics. The differences between the 2 groups were examined with the chi-square test for categorical variables and the independent t-test for continuous variables. RFS, CFS, and OS were evaluated using Kaplan-Meier analysis with univariate and multivariate logistic regression. P-values of less than 0.05 indicated statistical significance. All statistical analyses were performed using IBM SPSS Statistics ver. 25.0 (IBM Co., Armonk, NY, USA).

**RESULTS**

The basic characteristics of both groups, both before and after PSM, are presented in Table 1. Statistically significant differences were observed in sex (p=0.047), clinical stage ≥T3 (p<0.001), clinical stage N1 (p=0.001), and the distribution of Fuhrman grade (p<0.001). However, after PSM, the baseline characteristics between the 2 groups were well balanced and comparable. The mean age at the time of operation was 59.0±12.7 years in the control group and 58.1±12.5 years in the PRAE group, with a p-value of 0.468.

**Table 1. Baseline characteristics before and after propensity score matching**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Before propensity matching</th>
<th>After propensity matching</th>
<th>Control group (n=699)</th>
<th>PRAE group (n=121)</th>
<th>p-value</th>
<th>Control group (n=242)</th>
<th>PRAE group (n=121)</th>
<th>p-value</th>
<th>Standardized difference</th>
<th>Standardized difference</th>
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<tbody>
<tr>
<td>Age (yr)</td>
<td>59.0±12.7</td>
<td>58.1±12.5</td>
<td>0.468</td>
<td>-0.072</td>
<td></td>
<td>58.3±13.3</td>
<td>58.1±12.5</td>
<td>0.907</td>
<td>-0.014</td>
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<td>Female sex</td>
<td>205 (29.3)</td>
<td>47 (38.8)</td>
<td>0.047</td>
<td>-0.014</td>
<td></td>
<td>96 (39.7)</td>
<td>47 (38.8)</td>
<td>0.970</td>
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<td>BMI (kg/m²)</td>
<td>24.6±3.5</td>
<td>24.0±3.2</td>
<td>0.077</td>
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<td>24.0±3.4</td>
<td>24.0±3.2</td>
<td>0.994</td>
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<td>Diabetes mellitus</td>
<td>152 (21.7)</td>
<td>22 (18.2)</td>
<td>0.444</td>
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<td>44 (18.2)</td>
<td>22 (18.2)</td>
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<td>57 (47.1)</td>
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<td>120 (49.6)</td>
<td>57 (47.1)</td>
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<td>6 (2.5)</td>
<td>3 (2.5)</td>
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<tr>
<td>≥2</td>
<td>0</td>
<td>519 (74.2)</td>
<td>93 (76.9)</td>
<td>-0.077</td>
<td></td>
<td>196 (81.0)</td>
<td>93 (76.9)</td>
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<td>134 (19.2)</td>
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<td>36 (14.9)</td>
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<td>≥2</td>
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<td>10 (4.1)</td>
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<td></td>
<td>≥T3</td>
<td>107 (15.3)</td>
<td>50 (41.3)</td>
<td>&lt;0.001</td>
<td>0.102</td>
<td>100 (41.3)</td>
<td>50 (41.3)</td>
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<td>-0.043</td>
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<td>N1</td>
<td>33 (4.7)</td>
<td>16 (13.2)</td>
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<td>26 (10.7)</td>
<td>16 (13.2)</td>
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<td>Clear-cell type</td>
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<td>100 (82.6)</td>
<td>191 (78.9)</td>
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<td>Papillary type</td>
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<td>3 (5.4)</td>
<td>4 (3.3)</td>
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<td>Chromophobe type</td>
<td>49 (7.0)</td>
<td>10 (8.3)</td>
<td>28 (11.6)</td>
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<td>Others</td>
<td>21 (3.0)</td>
<td>7 (5.8)</td>
<td>10 (4.1)</td>
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<td>Fuhrman grade</td>
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<td></td>
<td>&lt;0.001</td>
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<td></td>
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<td>1.000</td>
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<tr>
<td></td>
<td>1</td>
<td>2 (0.3)</td>
<td>0 (0)</td>
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<tr>
<td></td>
<td>2</td>
<td>173 (24.7)</td>
<td>14 (11.6)</td>
<td>25 (10.3)</td>
<td>14 (11.6)</td>
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<tr>
<td></td>
<td>3</td>
<td>399 (57.1)</td>
<td>57 (47.1)</td>
<td>131 (54.1)</td>
<td>57 (47.1)</td>
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<tr>
<td></td>
<td>4</td>
<td>125 (17.9)</td>
<td>50 (41.3)</td>
<td>86 (35.5)</td>
<td>50 (41.3)</td>
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</tbody>
</table>

Values are presented as mean±standard deviation or number (%).
PRAE, preoperative renal artery embolization; BMI, body mass index; CKD, chronic kidney disease; ECOG, European Cooperative Oncology Group.

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was 58.2±13.0 years, with 143 (39.3%) of the patients being female. In terms of clinical stages, 150 (41.3%) were ≥cT3 and 42 (11.5%) were cN1. The pathology report indicated that 291 (80.1%) patients had clear-cell type RCC, and 334 (89.3%) had a Fuhrman grade of ≥3. After PSM, there was no significant difference in tumor size (76.4±32.6 mm vs. 79.2±27.3 mm, p=0.471) or renal nephrometry score (10.0±7.6 vs. 9.8±1.6, p=0.825).

The perioperative outcomes for both groups are detailed in Table 2. The PRAE group exhibited a higher postoperative transfusion rate (18.2% vs. 10.7%, p=0.049) and a greater amount of postoperative transfusion (0.7±1.9 packs vs. 0.3±0.9 packs, p=0.025) than the control group. However, there was no significant difference between the PRAE group and the control group in operation time (166.6±95.3 minutes vs. 155.5±74.2 minutes, p=0.263), estimated blood loss (360.4±732.0 mL vs. 293.4±596.6 mL, p=0.384), or length of hospital stay (7.7±4.9 days vs. 7.7±3.7 days, p=0.961).

The median follow-up period was 42.0 months. In terms of oncologic outcomes, the recurrence rate was significantly lower in the PRAE group compared to the control group (20.7% vs. 34.3%, p=0.007). However, no significant difference was observed between the PRAE group and the control group in terms of cancer-specific death (8.3% vs. 9.1%, p=0.793) or overall death (8.3% vs. 12.0%, p=0.281) (Table 3). Furthermore, the Kaplan-Meier analysis revealed no significant difference in RFS (p=0.283), CSS (p=0.173), or OS (p=0.442) between the 2 groups (Fig. 1).

Univariate analysis revealed that a higher recurrence rate was associated with clinical T stage ≥3 (odds ratio [OR], 4.275; p<0.001) and clinical N1 stage (OR, 2.407; p<0.008). Additionally, the absence of PRAE (OR, 2.005; p<0.008) was also linked to a higher recurrence rate. In the multivariate analysis, clinical T stage ≥3 (OR, 4.365; p<0.001), clinical N1 stage (OR, 2.405; p=0.020), and the absence of PRAE (OR, 2.293; p=0.004) were identified as independent predictive factors of recurrence (Table 4).

### DISCUSSION

Before RAE was introduced for the management of RCC [24], it was utilized in the treatment of various renal diseases. It has been acknowledged as a safe procedure with a low incidence of major complications [8]. However, the role of PRAE in the management of RCC remains a contentious issue among urologists [19]. According to the guidelines of the American Urological Association [25] and the National Comprehensive Cancer Network [2], there are no recommendations for PRAE prior to RN. Only the EAU guideline [4] suggests the use of RAE for the palliation of symptoms such as flank pain and hematuria, and notes that only selective PRAE could reduce intraoperative blood loss during PN. The current EAU guideline also states that there is no benefit to PRAE before routine RN.

The clinical role of PRAE prior to RN has been the subject of extensive debate in numerous studies. May et al. [16] reported that there was no survival advantage following PRAE in patients with RCC. In patients with RCC and an inferior vena cava thrombus, Subramanian et al. [26] have reported that PRAE not only fails to provide survival benefits, but also increases mortality and perioperative complications. Conversely, Zielinski et al. [17] have retrospectively assessed the role of PRAE in RN. In their study, patients were divided into a PRAE group (n=118) and a control group (n=116). The PRAE group exhibited statistically significant higher 5-year and 10-year survival rates. Some research has suggested that PRAE, followed by RN, may be associated with immunotherapeutic benefits due to lymphoproliferative responses and subsequent tumor necrosis, which could contribute to additional survival gains [20,27].

### Table 2. Perioperative outcomes between PRAE group and control group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PRAE group</th>
<th>Control group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation time (min)</td>
<td>166.6±95.3</td>
<td>155.5±74.2</td>
<td>0.263</td>
</tr>
<tr>
<td>Estimated blood loss (mL)</td>
<td>360.4±732.0</td>
<td>293.4±596.6</td>
<td>0.384</td>
</tr>
<tr>
<td>Postoperative transfusion</td>
<td>22 (18.2)</td>
<td>26 (10.7)</td>
<td>0.049</td>
</tr>
<tr>
<td>Postoperative transfusion (pack)</td>
<td>0.7±1.9</td>
<td>0.3±0.9</td>
<td>0.025</td>
</tr>
<tr>
<td>Hospital days (day)</td>
<td>7.7±4.9</td>
<td>7.7±3.7</td>
<td>0.961</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation or number (%).

PRAE, preoperative renal artery embolization.

### Table 3. Oncologic outcomes between PRAE group and control group

<table>
<thead>
<tr>
<th>Variable</th>
<th>PRAE group</th>
<th>Control group</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recurrence</td>
<td>25 (20.7)</td>
<td>93 (34.3)</td>
<td>0.007</td>
</tr>
<tr>
<td>Cancer-specific death</td>
<td>10 (8.3)</td>
<td>22 (8.1)</td>
<td>0.793</td>
</tr>
<tr>
<td>Overall death</td>
<td>10 (8.3)</td>
<td>29 (12.0)</td>
<td>0.281</td>
</tr>
</tbody>
</table>

Values are presented as number (%).

PRAE, preoperative renal artery embolization.
al. [19] have also reported an increase in natural killer cells following PRAE in patients with RCC, which may be influenced by interferon released from macrophages activated by tumor necrosis. However, there is currently no definitive evidence to suggest that PRAE provides survival benefits through an immunotherapeutic response in patients.
with nonmetastatic advanced RCC [1].

Other studies have proposed that PRAE is a safe and beneficial procedure, offering distinct technical advantages during subsequent RN in advanced high-risk RCC, including a reduction in surgical blood loss [11,12,28]. However, our study did not reveal a significant difference in operation time or estimated blood loss during surgery between the PRAE group and the control group. Moreover, contrary to previous studies, a higher percentage of patients who received postoperative transfusion (18.2% vs. 10.7%, p=0.049) and a greater number of red blood cell packs were used during transfusion in the PRAE group (0.7±1.9 packs vs. 0.3±0.9 packs, p=0.025). This was a retrospective study without randomization, and PRAE was performed on patients who were deemed to be surgically challenging or had aggressive tumors (thus, anticipated to have substantial intraoperative blood loss). Apart from tumor size and the renal nephrometry score, other anatomical features such as complex vasculature, which prompted the surgeons to perform PRAE, were challenging to quantify and statistically analyze accurately. Therefore, our results could have been affected by selection bias despite PSM.

Despite the issue of selection bias, the recurrence rate was notably lower in the PRAE group compared to the control group (20.7% vs. 34.3%, p=0.007). PRAE emerged as a statistically significant factor associated with the recurrence rate, alongside clinical T stage and N stage, in the multivariate analysis. The immunotherapeutic effects suggested by previous studies [19,20] may influence circulating cancer cells, potentially preventing recurrence. Given that a PSM was conducted with the clinical stage and pathologic report, it can be inferred that patients in both the PRAE group and the control group likely had similar oncologic characteristics. Moreover, there was no significant statistical difference in tumor size or the renal nephrometry score. However, considering the potential selection bias due to PRAE being performed on patients with challenging conditions, it can be inferred that the PRAE group may have had similar or even worse oncologic characteristics compared to the control group. Despite this, the PRAE group demonstrated a lower recurrence rate, suggesting an additional role for PRAE prior to RN. Further studies are needed to clarify the effects and roles of this procedure in advanced RCC patients. There were no significant differences in overall death or cancer-specific death between the 2 groups. Similarly, there was no significant difference in the Kaplan-Meier analysis of CSS or OS. However, given the relatively short follow-up period, the effect of PRAE on survival may have been underestimated. Therefore, studies with longer follow-up periods are necessary for a more comprehensive evaluation of the effects of PRAE.

This study has some potential limitations. First, due to the retrospective nature of the study, there may be potential selection bias, although we did employ PSM to mitigate this bias. Second, our study population was relatively small and our follow-up period was relatively brief, which may have contributed to the lack of significant difference observed in the Kaplan-Meier analysis. Third, we did not take into account the potential impacts of changes in medical practice and technology over nearly 2 decades on the study’s results. Changes in guidelines or technical advancements could have made potential RN candidates suitable for PN, which could also have introduced selection bias. Additionally, there were insufficient guidelines for PRAE for asymptomatic patients. As a result, PRAE may have been applied to patients who could potentially benefit from the procedure.

**CONCLUSIONS**

The results of our study suggest that PRAE for advanced nonmetastatic RCC could reduce recurrence rate. Therefore, performing PRAE before RN could be useful in the management of advanced nonmetastatic RCC. Considering that in our study, PRAE was performed on patients deemed to be surgical challenges or those with aggressive cancer, as assessed by our surgeons. Consequently, we cautiously propose the consideration of PRAE before RN when surgeons evaluate a patient as having an aggressive condition. However, we should also emphasize that proper guidelines or indications for PRAE are currently absent. The results should be interpreted with caution and further prospective randomized research is needed to provide evidence of our results.
NOTES

• Conflicts of Interest: The authors have nothing to disclose.
• Funding/Support: This study received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
• Author Contribution: Conceptualization: JN, GHJ; Data curation: JN, SHS; Formal analysis: JN, GHJ; Methodology: JN; Project administration: JKK, SKH; Visualization: JN SCL; Writing - original draft: JN; Writing - review & editing: JN, JKK, SSB
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REFERENCES


