Clipless laparoscopic adrenalectomy for pheochromocytoma

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Background: Laparoscopic adrenalectomy remains a challenging operation for pheochromocytoma (PCC) because of excessive secretion of catecholamines causing hemodynamic instability.

Objectives: To evaluate the use of the LigaSure vessel sealing system (Covidien-Medtronic) to secure hemostasis during laparoscopic adrenalectomy for PCC.

Methods: In this observational study we retrospectively reviewed a case series of 19 patients with preoperatively diagnosed PCC, who underwent laparoscopic adrenalectomy who underwent laparoscopic adrenalectomy using the LigaSure vessel sealing instead of using vascular clips or suturing. We report intraoperative findings, conversion rates, blood loss, operative time, morbidity, and postoperative outcomes.

Results: Surgery was performed successfully for 18 patients. Surgery for the remaining 1 patient of the present case series was converted to open adrenalectomy because of surrounding tissue invasion. No mortality or major morbidity was observed. Estimated blood loss was a mean (range 20−300) 153 mL (excluding the loss in the patient whose surgery was converted to open adrenalectomy). The pathology showed 6 patients with potentially malignant PCC (Pheochromocytoma of the Adrenal Scaled Score (PASS) ≥4).

Conclusions: The LigaSure device appears to be safe and effective in laparoscopic adrenalectomy for PCC. This clipless approach can be used with acceptable outcomes.

Keywords: Clipless, laparoscopic adrenalectomy, LigaSure, pheochromocytoma, treatment outcome

Pheochromocytoma (PCC) is an uncommon catecholamine-secreting neuroendocrine tumor originating from the adrenal medulla or from sympathetic ganglia chromaffin cells. Surgical removal is the only effective way to cure the disease, but this surgery carries a high risk of adverse cardiovascular events, visceral injuries, and intraoperative blood loss [1, 2].

Currently, laparoscopic adrenalectomy is the criterion standard treatment of adrenal tumors, including PCC [3]. Compared with the open adrenalectomy, there is less pain, less blood loss, a shorter hospital stay, and a more rapid return to work [4]. In the past, laparoscopic adrenalectomy for the treatment of the large PCCs (>6cm) was controversial because of the risk of malignancy and several complications, such as bleeding, conversion rate, and long operative time [5, 6]. However, after developments in surgical instrument technology, such as the Harmonic Scalpel (Ethicon Endosurgery) and the LigaSure vessel sealing system (Covidien-Medtronic), laparoscopic procedures are becoming safer and faster. Presently many surgeons accept that if there is no evidence of supposed malignancy, a laparoscopic approach is safe for large PCCs.

There have been few published studies reporting the use of the LigaSure vessel sealing system during laparoscopic adrenalectomy. However, we found no report that separately described the treatment of PCC using the LigaSure instrument [7-11]. The aim of this study was to retrospectively review the safety of clipless laparoscopic adrenalectomy for PCC with the use of the LigaSure vessel sealing system.

Materials and methods

Every patient had been fully informed of any potential risks that may be encountered during the surgery to be performed for adrenalectomy, and had provided their written informed consent to undergo the procedure. The protocol for this retrospective observational study was reviewed and approved by the Institutional Review Board of the Faculty of
The operations had been performed at a single surgical center at King Chulalongkorn Memorial Hospital by two surgeons experienced in adrenal surgery. During the period from January 2008 to November 2015, 19 patients with adrenal PCC underwent laparoscopic adrenalectomy. All patient data from this case series were retrospectively reviewed, including details of preoperative diagnostic tests, medications, intraoperative clinical records, tumor size, blood loss, and postoperative management, including complications encountered. Every patient had received antihypertensive drug therapy to stabilize blood pressure and heart rate until achieving a safe zone was achieved (blood pressure <160/90 mmHg, heart rate <100 bpm for at least 24 h before surgery with absence of electrocardiographic ST–T changes for at least 1 week).

Every adrenalectomy had been performed using a transperitoneal laparoscopic approach. Three trocars had been used on a left adrenalectomy, and 4 had been used where the adrenalectomy was on the right side. Pneumoperitoneum pressure was maintained at 12 mmHg and increased up to 15–18 mmHg when bleeding had obscured the view. In cases of left PCC, we had usually performed a “vein first” technique by ligating the adrenal vein with a 5 mm shaft diameter hand instrument, LigaSure V. Then the tumors had been separated from surrounding organs starting from superior to lateral regions, and finally detached from the kidneys. On the right side, we had started at the junction of renal vein and inferior vena cava, and dissected upward until adrenal veins had been identified. All adrenal veins and arteries had been ligated and transected with LigaSure. In one case of bilateral adrenalectomy, the patient had been repositioned after resection of the first adrenal to perform another procedure. For large PCCs, multiple adrenal veins had been expected; we had carefully mobilized the adrenals after ligation of some veins to avoid any hypertensive crisis from incomplete vein ligation. In one case, conversion to open surgery had been necessary because the tumor invaded surrounding organs and needed an en bloc operation. In that case, the pathology demonstrated a malignant PCC. The last patient of this series had continued taking antiplatelet medication (aspirin) when the operation was performed because he had cardiac balloon angioplasty with drug-eluting stent installed within the previous 3 months.

All surgical specimens had been retracted using specimen extraction bags. A drainage tube had not been placed routinely, but only in the case of blood oozing from a raw surface. All patients had been observed postoperatively in a surgical intensive care unit.

### Results

The cases of 19 patients (12 women and 7 men) who underwent laparoscopic adrenalectomy for 20 PCCs using the LigaSure vessel sealing system were studied. One patient had needed a bilateral adrenalectomy for PCC on both sides. Patient demographics are listed in Table 1.

**Table 1. Clinical characteristics of the patients and pheochromocytomas**

<table>
<thead>
<tr>
<th>Patients</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>12</td>
</tr>
<tr>
<td>Male</td>
<td>7</td>
</tr>
<tr>
<td>Mean age (range) years</td>
<td>37.8 (11–62)</td>
</tr>
<tr>
<td>Side</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>10</td>
</tr>
<tr>
<td>Left</td>
<td>10</td>
</tr>
<tr>
<td>Mean tumor size (range) cm</td>
<td>5.19 (1.9–10)</td>
</tr>
<tr>
<td>≤6 cm</td>
<td>15</td>
</tr>
<tr>
<td>&gt;6 cm</td>
<td>5</td>
</tr>
<tr>
<td>Pheochromocytoma of the Adrenal Scaled Score (cases)</td>
<td></td>
</tr>
<tr>
<td>&lt;4</td>
<td>14</td>
</tr>
<tr>
<td>≥4</td>
<td>6</td>
</tr>
<tr>
<td>Mean blood loss (range) mL</td>
<td>153 (20–300)</td>
</tr>
<tr>
<td>Mean operative time (range) min</td>
<td>114 (60–225)</td>
</tr>
</tbody>
</table>
Operations had been accomplished in 18 patients. The surgery for 1 patient had been converted to open surgery because of suspected malignancy. No blood transfusion had been needed for patients with successful laparoscopic surgery, but the patient for whom surgery had been converted had needed 2 units of blood replacement because of the en bloc surgery with wedge resection of the liver. There was no mortality in the present series. Minor morbidity occurred in two patients (one patients had pleural effusion and needed pleural tapping, another case had incisional hernia and underwent open surgical repair). An intraoperative hypertensive crisis occurred and was recorded in 3 cases. Intraoperative hypotensive episodes were reported in 3 cases, and these had been treated using crystalloid and vasopressor treatment. The Pheochromocytoma of the Adrenal Gland Scaled Score (PASS score) was <4 in 13 cases, ≥4 in 6 cases (a PASS ≥4 identified potentially malignant tumors).

Discussion
Since Gagner et al. reported the first laparoscopic adrenalectomy in 1992 [12], this procedure has been used widely to treat various adrenal pathology and has become the criterion standard treatment. Several studies have demonstrated a lower morbidity rate when compared with previous open adrenalectomy [13]. In recent years, several new advances have made laparoscopic surgery more convenient and safer.

The LigaSure vessel sealing system combines both pressure and bipolar thermolysis to seal the vessels up to 7 mm in diameter [14]. The heat energy is able to break down elastin and collagen in vascular walls, causing the walls to stick together [15]. A feedback device is used to control the sealing process and automatically monitors the optimal energy for vessel sealing. This process is considered safe and permanent. Now there are at least 3 different types of 5 mm LigaSure hand-instrument jaw types (Blunt tip, Dolphin tip, and Maryland jaw) (Figure). We found that the Dolphin tip is the most appropriate for adrenalectomy because its jaw is small and tapering, thus it is easy to manipulate in a small space and sufficient for sealing a blood vessel.

There are several reported studies indicating the effectiveness and safety of LigaSure use for laparoscopic adrenalectomy [7-11]. These studies also found that LigaSure was a good alternative to other bleeding control methods, such as vascular clips or suturing without concern for spontaneous displacement of clips or by instrument manipulation. In the present study, we evaluates the safety of LigaSure for surgery to treat cases of PCC.

Surgery for PCC remains challenging, because the secretion of catecholamines causes hemodynamic instability, the excessive vascularization of this kind of tumor, the problems in dissecting the adrenal gland from adhesions to adjacent organs, and often to major blood vessels, such as the renal vein. Over the past decade, several studies have shown that a laparoscopic approach has lower morbidity and mortality than traditional open surgery, particularly because it can decrease postoperative pulmonary infections and thromboembolic complications [16, 17]. Although the mortality and overall complications are gradually being reduced, several risks remain for treatment of PCC, either open or laparoscopic, including intraoperative blood loss, blood pressure instability, visceral organ injury, and some adverse cardiovascular events, e.g. stroke, pulmonary or cerebral edema, and myocardial infarction [1, 18-21]. For laparoscopic surgery of large PCCs (>6 cm), Toniato et al. [22] observed higher blood loss in PCC >6 cm. However, they concluded that PCC dimensions do not affect surgical outcome. Although several studies have not supported laparoscopy for large PCCs, data accumulating during the past dozen years shows that a laparoscopic approach is feasible and apparently safe for PCC >6 cm [23-26]. Improving perioperative management, and advances in anesthesiology and surgery have significantly reduced mortality and morbidity during perioperative adverse cardiovascular events and postoperative care. In case of a large PCC with
technical difficulty, the surgeon should not hesitate to convert to open surgery, especially where malignancy is suspected. However, there is data showing that PCC >6 cm in diameter has a lower tendency to become malignant than other adrenal lesions of similar size, and it is likely that size in itself cannot be used as an absolute contraindication for laparoscopic surgery, particularly if there is no evidence of local invasion [23].

In the present case series, we reported all patients who underwent laparoscopic adrenalectomy for PCC where the use LigaSure instead of a vascular clip was planned from the outset. Even in this small retrospective case series, we found that the overall results were comparable to those reported in the larger experience (Table 2).

Of the present case series of 19 patients, 6 had a pheochromocytoma >6 cm and surgery for 1 patient was converted to open surgery because of suspected malignancy. Larger tumors tended to be associated with more blood loss and longer operative time, but other outcomes were not significantly different. LigaSure worked to replace the use of vascular clips and suturing, even though a patient could not stop antiplatelet therapy. However, the authors accept that more patients should be evaluated and postoperative follow-up time should be longer to assess this LigaSure approach more thoroughly in laparoscopic surgery for pheochromocytoma.

**Conclusion**

Laparoscopic adrenalectomy is currently a standard treatment for adrenal tumors including pheochromocytoma. This operation is safe and effective if the patients are appropriately selected. We found clipless adrenalectomy with the use of the LigaSure vessel sealing system can be used routinely and has satisfactory outcomes.

**Conflict of interest statement**

We received no financial or other support from commercial sources; including the companies that make or market the LigaSure device. The authors declare that there is no conflict of interest in this research.

**Authors contributions**

AS conceived and designed the study. All authors (AS, KP, and PK) helped to acquire the data from patient records. AS analyzed and interpreted the data and drafted the manuscript. All authors critically revised the article, approved the final version for submission, and take full responsibility for all statements made in the manuscript.

**Table 2. Results of laparoscopic adrenalectomy in patients with pheochromocytomas**

<table>
<thead>
<tr>
<th>Authors</th>
<th>Patients</th>
<th>Mean operative time (min)</th>
<th>Estimated blood loss (mL)</th>
<th>Conversion (%)</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gagner (1996) [1]</td>
<td>23</td>
<td>230</td>
<td>–</td>
<td>0</td>
<td>22</td>
<td>0</td>
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<tr>
<td>Walz (2002) [28]</td>
<td>52</td>
<td>116</td>
<td>100</td>
<td>0</td>
<td>23</td>
<td>0</td>
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<tr>
<td>Jaroszewski (2003) [29]</td>
<td>47</td>
<td>140</td>
<td>80</td>
<td>11</td>
<td>4.8</td>
<td>0</td>
</tr>
<tr>
<td>Kercher (2005) [31]</td>
<td>80</td>
<td>169</td>
<td>97</td>
<td>0</td>
<td>7.5</td>
<td>0</td>
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<tr>
<td>Naya (2005) [32]</td>
<td>23</td>
<td>193</td>
<td>130</td>
<td>4.34</td>
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<td>0</td>
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<tr>
<td>Toniato (2007) [22]</td>
<td>40</td>
<td>78</td>
<td>100</td>
<td>3</td>
<td>2.5</td>
<td>0</td>
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<tr>
<td>Meyer-Rochow (2009) [33]</td>
<td>36</td>
<td>183</td>
<td>–</td>
<td>2.7</td>
<td>13.9</td>
<td>0</td>
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<tr>
<td>Castilho (2009) [34]</td>
<td>24</td>
<td>126</td>
<td>–</td>
<td>0</td>
<td>16.7</td>
<td>0</td>
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<tr>
<td>Nau (2010) [35]</td>
<td>33</td>
<td>142</td>
<td>–</td>
<td>12.1</td>
<td>6</td>
<td>0</td>
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<tr>
<td>Shen (2012) [36]</td>
<td>102</td>
<td>186</td>
<td>–</td>
<td>3</td>
<td>13.7</td>
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<tr>
<td>Conzo (2013) [27]</td>
<td>60</td>
<td>165</td>
<td>130</td>
<td>5</td>
<td>8.3</td>
<td>0</td>
</tr>
<tr>
<td>Present case series</td>
<td>19</td>
<td>114</td>
<td>153</td>
<td>5</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
References
27. Conzo G, Musella M, Corcione F, De Palma M,


