Effect of Surgeon Expertise on the Outcome in Primary Hyperparathyroidism

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Background: Success in surgery for primary hyperparathyroidism (PHPT) is thought to be closely linked to surgical expertise. We investigated the effect of the surgeon’s experience on the postoperative outcome in patients with PHPT.

Design: Cohort study with retrospective analysis.

Setting: University tertiary care center.

Patients: Two hundred thirty consecutive patients with PHPT. We excluded patients with prior cervical surgery, parathyroid carcinoma, multiple endocrine neoplasia types 1 and 2, and renal hyperparathyroidism.

Interventions: All 230 patients underwent bilateral neck exploration for PHPT.

Main Outcome Measures: We registered complication rates, fulfillment of predefined operative concepts, and operative time in 230 cervical revisions for PHPT and compared the results of experienced surgeons (40 or more cervical revisions for PHPT performed before 1988) with those of surgeons still in training.

Results: Two surgeons classified as experienced operated on 75 patients. Under supervision of these surgeons, most operative procedures (n=155) were performed by 12 different surgeons classified as less experienced. Complications were observed in 31 patients (13.5%) with no statistical difference between the specialists and the less-experienced surgeons ($P=.85$). The ability to demonstrate 4 or more parathyroid glands was significantly increased for the specialists (74.7% vs 51.6%; $P<.001$), who also terminated the operation earlier (average, 15 minutes; $P<.001$).

Conclusion: In an analysis of 230 operations for PHPT in patients without prior neck surgery, no effect of the surgeon’s experience on postoperative outcome was demonstrated. Under the supervision of experienced endocrine surgeons, less-experienced surgeons perform cervical revisions for PHPT with comparable results, although with longer operating time.

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THE OPERATION for primary hyperparathyroidism (PHPT) is a standard procedure in endocrine surgery. However, success in this type of surgery is dependent on a meticulous preparation of the cervical structures, which enables identification of all pathological findings of parathyroid glands. The rate of persistent hyperparathyroidism after surgery has been closely associated to the individual surgeon’s experience with this disease. Doppman pointed out that finding a surgeon with experience in this type of surgery is the most effective way to avoid unsuccessful cervical revisions. Although the value of the surgeon’s experience for the outcome in this field of endocrine surgery has often been stressed, surprisingly few articles have been published analyzing individual surgeons’ results.

We analyzed the effect of a surgeon’s experience on the outcome of hyperparathyroid surgery.

RESULTS

During the observation period 14 surgeons performed between 1 and 44 operations for PHPT in patients without prior neck surgery. While 4 surgeons at the beginning of the observation period already had experience in surgery for PHPT, 10 surgeons did their first revisions for PHPT during the study period. Two surgeons fulfilled the criteria of 40 or more cervical revisions for PHPT at the beginning of the study and therefore were classified as ex-
PATIENTS AND METHODS

Between January 1988 and December 1995, 301 patients undergoing cervical exploration for PHPT were prospectively registered at the Department of Surgery at the University of Heidelberg, Heidelberg, Germany. Only patients with benign PHPT and no history of prior cervical operations were included in the study. Therefore, all patients with reoperations after thyroid surgery or unsuccessful parathyroid surgery, parathyroid carcinoma, multiple endocrine neoplasia types 1 and 2, and renal hyperparathyroidism were excluded from the study.

Two hundred thirty patients fulfilled the inclusion criteria for the investigation. The mean age was 39 years (SD, 14.3 years; median, 60 years) with the youngest patient aged 15 years and the oldest aged 87 years. Seventy-three percent of patients were female. The indication for the surgical revision was laboratory proof of PHPT, with elevated serum parathyroid hormone levels, hypercalcemia, and hypophosphatemia. Cervical ultrasonography was performed in 180 patients (78.3%) as an optional localization procedure. The suspected adenoma localization was described in relation to the thyroid gland: the corresponding quadrants were named left or right inferior and left or right superior. The examination was classified as correct when surgical and histological studies confirmed the location of the adenoma in the cervical quadrant as described by the ultrasonographic examination. A preoperative laryngoscopy was mandatory to document vocal cord function. The standard operative procedure included the visualization of all 4 parathyroid glands, adenoma extirpation, and biopsy of a normal gland. All specimens were histologically confirmed by frozen-section examination during the operation. If after conventional revision no adenoma could be identified, cervical thymectomy was performed in cases of missing lower parathyroid glands. A revision of the parapharyngeal and retroesophageal space was undertaken in cases of missing upper parathyroid glands. If still no adenoma was found, subtotal resection of both thyroid glands terminated the procedure. A partial sternotomy was not part of the initial cervical revision and would only be performed in a reoperation after extended localization procedures including highly selective venous catheterization. During postoperative recovery, serum calcium levels were regularly measured and oral supplementation was given if hypocalcemia became symptomatic. Before the patient was discharged from the hospital, serum parathyroid hormone levels were analyzed. Vocal cord function was examined in all patients by an independent physician and followed up for up to 2 years in cases of abnormal findings.

All surgeons performing operations during the observation period were included in the study. Fourteen different surgeons, all board certified with extensive experience in cervical surgery, performed the cervical revisions. Because we were interested in the influence of education and personal experience on the rate of complications in parathyroid surgery, experienced and less-experienced surgeons were separated into 2 groups. We defined surgeons to be experienced for this procedure when their personal records included 40 or more cervical revisions for PHPT at the beginning of the observation period in 1988.

All operative procedures performed in combination with parathyroidectomy (eg, thyroid resection or endarterectomy of the carotid artery) were documented. The consultation of a specialist in cases of intraoperative problems was additionally noted.

All complications aside from transient hypoparathyroidism were included in the investigation. Transient hypoparathyroidism (requiring calcium or vitamin D supplementation < 6 months) was excluded because the physiologically occurring increase in calcium uptake into the bone seems to be independent of the integrity of the surgical procedure. Further parameters for quality evaluation were the intraoperative demonstration of at least 4 parathyroid glands and the fulfillment of the standard adenectomy with 1 biopsy of a normal gland. Finally, the time necessary for the procedure was analyzed for the individual surgeon. Statistical analysis was performed using the SAS statistical software, version 6.12 (SAS Institute, Cary, NC). The 2-tailed Fisher exact test was used for the comparison of proportions. The corresponding 95% confidence intervals (CIs) for the estimated difference between sample proportions were constructed using $N_1 - N_2 / \sqrt{\hat{p}_1(1-\hat{p}_1) + \hat{p}_2(1-\hat{p}_2)}$. The Mann-Whitney U test was applied to compare subgroups of patients with respect to operation time. Statistical significance was assumed at $P<.05$.

In the postoperative course we observed 36 complications in 31 patients (13.5%) (Table 1). These were all caused by local conditions. There were no deaths. The single complication observed most often was recurrent laryngeal nerve palsy (7.8%). All pathological findings described in the initial postoperative laryngoscopy, including partial dysfunctions of the vocal cord, were recorded. While 5 patients (2.2%) continued to have nerve palsy during follow-up, 13 patients recovered and had normal vocal cord function on reexaminations performed between 6 weeks and 2 years after the operation. Four patients developed postoperative bleeding or major hematoma, 2 of which necessitated reoperation; all had an uneventful further recovery. Two patients received medication for hypoparathyroidism 2 years after the operation and were classified as permanently hypoparathyroid. With 7 patients remaining hypercalcemic, the cure rate for PHPT reached 97%.

Cervical thymectomy in search of an adenoma was done in 19 patients. This procedure led to the detection of 12 adenoamas, 1 gland with hyperplasia, and 1 normal gland. Five specimens did not contain parathyroid tissue. As a specific complication of this procedure, 1 patient developed a postoperative pneumothorax and was treated by closed pleural drainage for 5 days.

Of all thyroid resections undertaken, only 6 were necessary to search for suspected parathyroid adenomas. These procedures led to the identification of 5 adenomas classified as intrathyroidal. All remaining thyroid resections (n = 91) were performed for thyroid abnormalities independent from parathyroid disease. While the postoperative complication rate reached 18.6% after additional thyroid
resection vs 9.8% after parathyroid adenomectomy alone, this difference of 8.8% (95% CI, 0.5%-18%) did not reach statistical significance (P=.08).

Of 180 cervical ultrasonograms performed, 104 (57.8%) predicted the appropriate adenoma location. These were evenly distributed among the different surgeons. The complication rate was not increased if the preoperative localization was not done, wrong, or not successful (12/126; 9.5%) compared with a correct prediction of the adenoma location (19/104; 18.3%) (P=.08; difference 8.8%; 95% CI, −0.3% to 17.8%). The time in the operating room was independent of the success of the localization procedure. Whether or not cervical ultrasonography was successful, the median time for performing the cervical revision was 95 minutes (P=.42).

The individual surgeons’ rates of complications ranged from 0% to 33.3%. In comparing the surgeons defined as specialists with those less experienced we observed 11 complications (9 patients) in 75 operations for the specialists; the other group had 25 complications (22 patients) in 155 operations (P=.08; difference 8.8%; 95% CI, −0.3% to 17.8%).

An analysis of the influence of the cumulative experience gained during the observation period did not demonstrate a clear learning curve for the individual surgeons. Examples of the number of complications occurring each year are given for 1 specialized surgeon and 1 surgeon who first did parathyroid surgery during the study period (Figure).

The ability to follow the operative principle of removal of all adematous glands and a biopsy of 1 normal gland varied among the surgeons (Table 2). However, the variation among the analyzed groups (77.3% of experienced surgeons vs 73.5% of less-experienced surgeons following the procedures) demonstrated no significant difference (P=.63; difference 3.8%; 95% CI, −8% to 15.5%). Another defined quality measurement was the ability to demonstrate all parathyroid glands (at least 4). Here, experienced surgeons were more successful in fulfilling this criterion (56/75; 74.7%) in comparison with the surgeons in training for parathyroid surgery (80/155; 51.6%) (P<.001; difference 23.1%; 95% CI, 10.5% to 35.7%).

Another difference between the 2 groups was length of operating time. The procedure was significantly shorter when an experienced surgeon operated in comparison with a less-experienced surgeon (median operation time, 85 vs 100 minutes, P<.001). This effect was independent of synchronous thyroid resections, which were evenly distributed among the 2 groups (42.7% vs 41.9%). In general, an extra 33 minutes had to be calculated if a thyroid resection was necessary (97 patients).

### Table 1. Complications in 230 Patients Undergoing Primary Cervical Revision for Primary Hyperparathyroidism

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>199 (86.5)</td>
</tr>
<tr>
<td>Bleeding</td>
<td>4 (1.7)</td>
</tr>
<tr>
<td>Infection</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Recurrent laryngeal nerve palsy</td>
<td>5 (2.2)</td>
</tr>
<tr>
<td>Transient recurrent laryngeal nerve palsy</td>
<td>13 (5.7)</td>
</tr>
<tr>
<td>Hypoparathyroidism</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Persistent hypoparathyroidism</td>
<td>7 (3)</td>
</tr>
<tr>
<td>Various*</td>
<td>3 (1.3)</td>
</tr>
<tr>
<td>Mortality</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

* Includes 1 pneumothorax, 1 palsy of the external branch of the superior laryngeal nerve, and 1 thyroid resection due to ischemic alteration of the gland after prolonged neck dissection.

### Table 2. Individual Results of 14 Surgeons Performing Cervical Revisions in 230 Patients With Primary Hyperparathyroidism

<table>
<thead>
<tr>
<th>Surgeon No.</th>
<th>No. of Operations</th>
<th>No. of Years Participating</th>
<th>Concept Fulfillment, %</th>
<th>Demonstration of 4 Glands, %</th>
<th>Median Operation Time, min</th>
<th>Complications, %</th>
</tr>
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<tbody>
<tr>
<td>Experienced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>44</td>
<td>7</td>
<td>86.4</td>
<td>70.5</td>
<td>87.5</td>
<td>13.6</td>
</tr>
<tr>
<td>2</td>
<td>31</td>
<td>8</td>
<td>64.5</td>
<td>80.6</td>
<td>80</td>
<td>9.5</td>
</tr>
<tr>
<td>Less experienced</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>33</td>
<td>3</td>
<td>66.7</td>
<td>72.7</td>
<td>80</td>
<td>24.3</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>8</td>
<td>86.2</td>
<td>55.2</td>
<td>85</td>
<td>17.2</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>4</td>
<td>77.3</td>
<td>40.9</td>
<td>112.5</td>
<td>9.1</td>
</tr>
<tr>
<td>6</td>
<td>21</td>
<td>6</td>
<td>71.4</td>
<td>57.1</td>
<td>102.5</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>15</td>
<td>2</td>
<td>53.3</td>
<td>26.6</td>
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<td>9</td>
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<td>7</td>
<td>2</td>
<td>42.9</td>
<td>57.1</td>
<td>165</td>
<td>14.3</td>
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<tr>
<td>11</td>
<td>6</td>
<td>4</td>
<td>66.7</td>
<td>0</td>
<td>130</td>
<td>16.7</td>
</tr>
<tr>
<td>12</td>
<td>3</td>
<td>2</td>
<td>100</td>
<td>33.3</td>
<td>115</td>
<td>33.3</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>100</td>
<td>95</td>
<td>0</td>
</tr>
<tr>
<td>14</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>0</td>
<td>140</td>
<td>0</td>
</tr>
</tbody>
</table>

* Percentage of operations with histological confirmation of at least 1 parathyroid adenoma and 1 normal gland.

Parathyroid surgery, with its meticulous preparation in the neck, has long been recognized as a delicate procedure with success being highly dependent on surgical skill and experience. Since Mandl successfully treated a patient with osteitis fibrosa cystica through the extirpation of a parathyroid tumor, this field of endocrine surgery has become very successful, with reported healing rates of 95% in patients with PHPT.

Throughout the literature the importance of the surgeon’s skill to the successful treatment of this disease is
so even after adenomatous transformation.5 Furthermore, such biopsies in search for histological proof of every parathyroid tissue in primary PHPT are harmful to the patient, as demonstrated by an increased rate of persistent postoperative hypoparathyroidism.18 These few points may explain why the surgeon with experience in dissecting the sensitive neck structures and the knowledge of different parathyroid abnormalities should be the one to operate on patients with parathyroid disease. On the other hand, all teaching institutions have the obligation to educate new endocrine surgeons, who must learn to effectively treat patients with PHPT.16,19

One question had to be answered in developing the study design: How and when can an endocrine surgeon be defined as experienced for parathyroid surgery? No definitive answer is given in the literature. Although multiple analyses demonstrate that the experienced surgeon provides better results in variant forms of surgery,20-22 none supplies a definitive number of operations after which a surgeon approaches a plateau in the individual learning curve. We decided to select 40 operations overall, because this number far exceeds the general experience for parathyroid surgery gained in residency programs,23 and furthermore exceeds the estimated learning curve for complex visceral surgery such as D2 lymphadenectomy for gastric cancer.24

The effect of a surgeon’s experience on operative outcome was analyzed in initial cervical exploration for primary PHPT covering an observation period of 8 years. In regard to the overall morbidity, our study underlines the importance of prospective data acquisition, because otherwise rare complications like pneumothorax or superior laryngeal nerve palsy might easily be missed in solely retrospective analysis. Following our definition of experienced surgeons (>40 explorations for PHPT at the beginning of the observation period), we could not demonstrate a significant difference for postoperative complications between specialists and a group of 12 surgeons with less experience. This included recurrent laryngeal nerve palsies, which occurred more often than usually reported. However, a transient palsy or partial disturbances, often not described in the literature or probably described with terms such as “temporary hoarseness,” were responsible for the majority of primary vocal cord dysfunctions reported. Recently, a clinical trial was started to evaluate the usefulness of a new monitoring device for recurrent laryngeal nerve function during cervical operations.25 Whether this intraoperative examination will be able to reduce the rate of transient and permanent recurrent laryngeal dysfunctions remains to be established.

The lack of difference between the teacher and the trainee in parathyroid surgery as documented in the current study demonstrates the importance of including parathyroid surgery in the curriculum of endocrine surgery.19 Reasons for this result are unclear; the observed difference of 2.2% in complication rates is still too small to be evaluated significantly. The 95% CI ranges from −7% to 11%, showing the imprecision caused by the limited sample size of 230 operations.26 The rates of complications in the group of less-experienced PHPT surgeons were acceptable because all had extensive experience with thyroid surgery prior to their first explorations for PHPT. Finally, the initial procedures were assisted by a specialist who also could be called in to assist in all cases of intraoperative difficulties. There are few data to be compared with this finding in general. Ready et al8 analyzed the results of parathyroidectomy in the West Midlands, England, in 1992. Twenty general surgeons from different institutions performed 101 operations with a mean number of 5 cases per surgeon. Although they did not statistically calculate the results of the different surgeons, it was striking that all unsuccessful explorations (n=4) were performed by surgeons who had performed fewer parathyroidectomies per year than the average.

In a report from Scandinavia,21 results for parathyroid surgery from 55 clinics were analyzed. Although the number of surgeons performing parathyroid surgery in each clinic was documented (1 in 33%, 2 in 51%, and 3-5 in 16% of the clinics), the analysis focused on the overall results of each hospital. Departments with a frequency of more than 10 cervical revisions for parathyroid disease per year had significantly fewer cases of persistent hypercalcemia than hospitals where fewer than 10 procedures were performed annually.

In another retrospective study, Chen et al27 found shorter lengths of stay for parathyroidectomies in endocrine centers compared with 52 community hospitals in the state of Maryland. None of the perioperative mortality (0.6% overall) occurred in 1 of the 2 endocrine centers with the highest rates of operations for PHPT. Unfortunately, no data were available regarding overall morbidity from the community hospitals. Therefore no conclusions could be drawn regarding individual surgeons’ results.

Doppman recently was cited by Vierhapper, with his statement that “a successful preoperative localization turns an average surgeon into an excellent one.”28 In our analy-
sis, the success of the localization procedure did not have any influence on the outcome of surgery or on time in the operating room. This is in contrast to some reports in which a correct localization procedure reduced time in the operating room, especially when performing limited neck explorations guided by preoperative examinations. When routinely performing bilateral neck exploration, the influence of localization procedures on operating time diminishes.

What criteria are left to separate the specialist from the less-experienced surgeons in hyperparathyroidism? One defined criterion was the ability to demonstrate all parathyroid glands. In 1991, van Heerden and Grant reported that visualizing all parathyroid glands was possible in 44% of attempted cases. In our study, this was exceeded by both groups of surgeons; however, there still was a significantly higher proportion for the experienced surgeons. The second difference belongs to the operating time. The experienced surgeons terminated the procedure 15 minutes earlier than did the less-experienced surgeons. In terms of education, this lengthening of operating time seems acceptable.

In conclusion, the analysis of the effect of the surgeon's experience revealed no difference in postoperative outcome in primary cervical revisions for PHPT in our teaching institution. Gradual differences characterize the specialist as able to demonstrate more parathyroid glands and to terminate the operative procedure earlier than the surgeons with less experience. We conclude that parathyroid surgery is feasible for education in endocrine surgery under the close supervision of experienced members of the faculty.

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REFERENCES

The question of who should do or, more importantly, who should be trained to do parathyroid surgery remains controversial. There is no question that parathyroid surgery performed by inexperienced surgeons in an unsupervised setting leads to high failure rates and, presumably, higher rates of reoperation. The article by Willeke et al compares parathyroidectomy undertaken by “experienced” endocrine surgeons (having performed >40 parathyroid procedures themselves) with parathyroidectomy performed by surgeons in training. The results confirm what has been previously demonstrated with respect to other endocrine procedures such as thyroidectomy; namely, that surgeons in training, provided they are appropriately supervised, can perform complex surgical procedures with the same safety and expected outcomes as experienced surgeons. In this study there was no difference in complication rates or in the rate of a successful outcome (removal of all abnormal glands and biopsy of 1 normal gland), although close supervision by experienced members of faculty in the case of intraoperative problems was implicit in the study. The inexperienced surgeons took longer and were less likely to find all 4 glands, but this did not influence outcome.

Parathyroid surgery, in expert hands, is a very cost-effective procedure. The potential for long-term medical treatment of primary hyperparathyroidism (as an alternative to surgery) by calcimimetic agents, including modulators of the calcium-sensing receptor such as NPS R568, underscores the need for parathyroidectomy to be performed as a cost-effective procedure. The introduction of minimally invasive parathyroidectomy, either needlescopic or probe-directed, further adds to the pressure for quality outcomes. It is vital that surgeons who wish to undertake parathyroid surgery have received appropriate training in the meticulous techniques required, and have an extensive knowledge of embryological and anatomical variations intrinsic to this type of surgery.

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IN OTHER AMA JOURNALS

ARCHIVES OF INTERNAL MEDICINE

Communicating Do-Not-Resuscitate Orders With a Computer-Based System

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Background: Do-not-resuscitate (DNR) orders for critically ill patients are frequently miscommunicated between attending physicians, house staff, and nurses. A computer-based system was developed to improve the communication of a procedure-specific DNR order form.

Methods: Concordance of understanding of patients’ DNR status was measured with the use of unstructured DNR orders (period 1), procedure-specific DNR order forms (period 2), and procedure-specific DNR order forms administered with a computer-based communication system (period 3). The 3 components of the DNR order assessed were (1) the clinical events to which the DNR order applied, (2) whether the DNR order withheld all elements of cardiopulmonary resuscitation, and (3) whether other treatments were to be withheld.

Results: For the 147 patients, the computer-based system in period 3 (n = 71) improved concordance for attending physicians and nurses or residents for all 3 of the DNR components compared with period 1 (n = 40) and some of the DNR components compared with period 2 (n = 36). Concordance was “substantial” or “almost perfect” as measured by the \( \kappa \) statistic during period 3. The proportion of agreement for the composite of all 3 components of the DNR order increased during each period \( (P<.001, \text{period 3 vs period 1}) \). Overall agreement between all caregivers for the composite DNR order also improved from period 1 (22.2%) to period 2 (47.8%) and period 3 (61.9%; \( P<.001 \) vs period 1). Errors in order entry were detected by physicians because of the computer system and corrected in 9.9% of DNR orders in period 3. Progress note documentation of DNR status did not improve during period 3. The procedures of period 3 were considered acceptable by the physician and nursing staff.

Conclusion: A computer-based system combined with a procedure-specific DNR order form improves communication of patients’ DNR status in a critical care setting. (1998;158:1090-1095)

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