Am J Otolaryngol 40 (2019) 102292

Contents lists available at ScienceDirect

Am J Otolaryngol

journal homepage: www.elsevier.com/locate/amjoto

# A faster parathyroidectomy: Techniques to shorten non-surgical operating room time☆

Ayaka J. Iwata[a], Anna S. Wertz[a], Spandana Alluri[b], Michael C. Singer[a,*]

[a] Department of Otolaryngology — Head and Neck Surgery, Henry Ford Health System, 2700 West Grand Boulevard, Detroit, MI 48202, United States of America
[b] Wayne State University School of Medicine, 540 E Canfield St, Detroit, MI 48201, United States of America

ARTICLE INFO

*Keywords:*
Parathyroidectomy
Operative time
Efficiency

ABSTRACT

*Objective:* To assess the capacity of different techniques to reduce non-operative times during parathyroid surgery. The impact of monitored anesthesia care (MAC) instead of general anesthesia, and the pre-operative placement of a second peripheral intravenous catheter (PIV) were analyzed.

*Methods:* A retrospective case series at an academic medical center was performed to study patients undergoing parathyroidectomy by a single surgeon between November 2013 and October 2016. Three operating room (OR) time measurements were compared: pre-incision time, post-closure time, and total OR time.

*Results:* Surgeries performed under MAC ($n = 21$) had statistically shorter pre-incision (33.2 min vs. 39.7 min, $p < .001$), post-closure (10.1 min vs. 16.2 min, $p = .002$), and total operative times (113.0 min vs. 151.5 min, $p < .001$) compared to those in which general anesthesia ($n = 169$) was used. Of the 169 patients who underwent general anesthesia, 25 had a second PIV placed preoperatively and 144 had only a single PIV. All 3 time periods were statistically shorter in patients who had a second PIV versus those who had only a single PIV (pre-incision 32.2 min vs. 41.0 min, $p < .001$; post-closure 12.2 min vs. 16.9 min, $p < .001$; total 117.9 min vs. 157.4 min, $p < .001$).

*Conclusions:* In patients undergoing parathyroid surgery in which ioPTH levels will be used, the placement of a second PIV in the pre-operative holding area and performance of surgery under MAC can significantly shorten non-operative and total OR time.

## 1. Introduction

Parathyroid surgery continues to evolve to optimize outcomes for patients suffering from hyperparathyroidism. Historically, surgical treatment of primary hyperparathyroidism required a bilateral neck exploration (BNE) with identification of all four parathyroid glands, followed by the removal of any abnormal appearing glands [1]. It was often a tedious operation that heavily relied on experienced surgical judgment. These cases could require a relatively prolonged operative time, utilization of general anesthesia, frozen-section assessment, inpatient admission, drain placement, and a long cervical incision [2–4].

Advances in pre-operative localization studies and the introduction of intraoperative parathyroid hormone (ioPTH) monitoring assays have revolutionized parathyroid surgery, and allowed the development of minimally invasive parathyroidectomy (MIP) techniques. MIP (or focused neck exploration) can provide abundant benefits to patients, including a more cosmetically pleasing scar, reduced operative time, less post-operative pain, a shorter recovery time, and a lower complication rate [2,4–6]. Further technological advances have allowed the feasibility of other techniques for targeted parathyroidectomy, including minimally invasive video-assisted (MIVAP) [7,8], endoscopic [9,10], radio-guided [11,12], and microinvasive parathyroidectomy [13].

While surgeons continue to debate the value of these various techniques and argue over the superiority of BNE versus MIP, all agree that surgical efficiency is an important aspect of any surgical technique. In an era when health care costs are a constant focus of patients, corporations, policy makers and the government, costs and charges arising from operative procedures should be considered in determining optimal techniques. For surgical finances, time in the operating room is a crucial factor. Overall duration in the operating room (OT) is made up of surgical times (ST) and non-surgical times (NST). The non-surgical period includes the pre-incision and the post-closure times (including emergence from anesthesia).

For parathyroidectomy, most studies examining cost have focused

☆ Presented at: American Academy of Otolaryngology — HNSF, Chicago, IL, Sep 10–17, 2017.

* Corresponding author.
*E-mail address:* msinger1@hfhs.org (M.C. Singer).

https://doi.org/10.1016/j.amjoto.2019.102292
Received 4 July 2019

**Table 1**
Demographics.

| | General anesthesia ($n$ = 169) | Monitored anesthesia care ($n$ = 21) | $p$-Value | 1 Large bore PIV* ($n$ = 144) | 2 Large bore PIVs ($n$ = 25) | $p$-Value |
|---|---|---|---|---|---|---|
| Age (years) | 58.0 ± 13.3 | 64.3 ± 16.5 | 0.051 | 58.3 ± 13.7 | 56.4 ± 11.1 | 0.50 |
| Sex (% female) | 79.8 | 76.2 | 0.70 | 79.9 | 76.0 | 0.66 |
| Height (m) | 1.65 ± 0.09 | 1.66 ± 0.10 | 0.55 | 1.64 ± 0.09 | 1.68 ± 0.09 | 0.08 |
| Weight (kg) | 85.8 ± 25.8 | 75.5 ± 14.6 | 0.07 | 86.2 ± 26.1 | 90.0 ± 21.4 | 0.49 |
| BMI† | 31.5 ± 8.7 | 27.9 ± 5.0 | 0.06 | 31.8 ± 8.7 | 31.9 ± 6.9 | 0.94 |

Plus-minus values are mean ± standard deviation.
* PIV: peripheral intravenous line.
† BMI: body mass index.

on ST. A number of authors have reported that MIP is a faster procedure and thus results in lowered treatment costs [5,14–16]. These studies largely consider improving ST, the time from the initial incision to the closure of the wound. Interventions that have been investigated to reduce ST include use of a gamma probe for guidance [3], faster ioPTH assays [17,18], and the use of local anesthesia [4,19].

To date, efforts at reducing NST in parathyroid surgery have attracted limited attention. Given that up to 40–45% of total OT is NST, any reduction in NST could significantly impact operative costs. We examined the possible impact that pre-operative placement of a dedicated peripheral intravenous catheter (PIV) for ioPTH monitoring and use of monitored anesthesia care (MAC) may have on NST during parathyroidectomy.

## 2. Methods

From November 2013 to October 2016, all parathyroidectomies performed by a single surgeon (M.C.S.) at Henry Ford Health System were retrospectively reviewed. Patients with a diagnosis of primary hyperparathyroidism who underwent initial surgery were included. Exclusion criteria included surgery for secondary or tertiary hyperparathyroidism, reoperative surgery, or concurrent thyroid surgery. As ST was not being assessed, surgical techniques varied. The majority of patients underwent MIP (including MIVAP) but a number underwent BNE. Patients who underwent BNE without PTH monitoring were also excluded. The study protocol was approved by the Institutional Review Board.

In our practice, in cases in which general anesthesia is used, a baseline ioPTH level is obtained after anesthesia is induced but before the skin incision is made. For cases with MAC, the level is drawn after the patient is positioned on the operating table. Additional, post-excision levels are acquired at 5, 10, and 15 min after gland excision. For ioPTH monitoring, dual criteria were required to determine cure: an ioPTH decrease > 50% from the baseline level and a drop into the normal range for PTH.

For the study cohort, all patients had placement of a dedicated second PIV (in the contralateral arm to the functional PIV) achieved in the pre-operative holding area. Consequently, these patients all were brought to the OR with two PIVs. Blood samples for the ioPTH monitoring were drawn through the dedicated PIV after anesthesia induction. Prior to the implementation of this system, blood was collected either through a PIV that was placed after induction in the OR or through straight phlebotomy of a peripheral vein. For comparing NST in patients with one versus two PIVs placed in the pre-operative holding area, those who underwent the surgery under MAC were excluded.

With regards to anesthesia, the decision to utilize general anesthesia versus MAC was discussed with the patient and made on a patient-by-patient basis. For surgeries performed with MAC, mild sedation was delivered intravenously and managed by anesthesia. Additionally, a transverse cervical nerve block was achieved with injection of 0.25% bupivacaine. The incision site was also injected.

The OT and ST were obtained from the electronic medical records for each surgery. NST was calculated by combining the pre-incision (PIT) and post-closure (PCT) times. PIT was considered from the time of patient arrival into the operating room until the surgical incision was made. PCT was defined as the time from incision closure until the patient exited the operating room.

Mean time comparisons between groups of subjects were analyzed using the Student's $t$-test to determine whether they were statistically different. Alpha was set at 0.05. Mean values are reported as mean ± standard deviation.

## 3. Results

190 patients who met all requisite criteria underwent first-time surgery for primary hyperparathyroidism during the study period. General anesthesia was used in 169 patients and 21 of them underwent surgery with MAC. Out of those who underwent general anesthesia, 144 patients had one PIV placed in the pre-operative holding area, and 25 patients had two PIVs placed prior to entering the operating room. Table 1 demonstrates that age, sex, height, weight, and body mass index (BMI) were not statistically different between the paired comparison groups under study.

Surgeries performed under MAC had statistically shorter PIT (33.2 min vs. 39.7 min, $p < .001$) and PCT (10.1 min vs. 16.2 min, $p = .002$) compared to their counterparts who received general anesthesia. Total OT (113 min vs. 151.5 min, $p < .001$) was also shorter in the patients managed with MAC (Table 2). Of the 21 patients managed with MAC, 18 underwent MIP and 3 had BNE. No patient required conversion from MAC to general anesthesia.

For assessing the impact of a second PIV, complete data was available for 169 patients. Of these, 25 patients had a second dedicated PIV placed in the pre-operative holding area. The remaining 144 patients went to the operating room with just a single PIV. In these patients, blood was obtained in a manner as described in the methods section. As demonstrated in Table 3, all three studied time periods (PIT, PCT, OT)

**Table 2**
General anesthesia vs. monitored anesthesia care.

| | General anesthesia ($n$ = 169) | Monitored anesthesia care ($n$ = 21) | $p$-Value |
|---|---|---|---|
| Pre-incision time (min) | 39.7 ± 7.2 | 33.2 ± 5.7 | < 0.001 |
| Post-closure time (min) | 16.2 ± 5.2 | 10.1 ± 2.1 | 0.002 |
| Total operating room time (min) | 151.5 ± 23.0 | 113.0 ± 17.6 | < 0.001 |

Plus-minus values are mean ± standard deviation.

**Table 3**
One large bore PIV vs. two large bore PIV.

| | 1 Large bore PIV* ($n$ = 144) | 2 Large bore PIVs ($n$ = 25) | $p$-Value |
|---|---|---|---|
| Pre-incision time (min) | 41.0 ± 9.5 | 32.2 ± 4.2 | 0.015 |
| Post-closure time (min) | 16.9 ± 9.5 | 12.2 ± 4.2 | < 0.001 |
| Total operating room time (min) | 157.4 ± 46.2 | 117.9 ± 36.1 | < 0.001 |

Plus-minus values are mean ± standard deviation.
* PIV: peripheral intravenous line.

were statistically shorter in patients who had a second PIV placed prior to entering the operating room.

## 4. Discussion

With an increasing emphasis on healthcare costs in the United States, efficiency in the operating room has commanded significant attention over the last few years. Costs related to the operating room can be reduced by optimal scheduling of cases and staffing, streamlining operating room inventory and storage, and minimizing unnecessary use of equipment and supplies. Different healthcare systems and researchers have reported on a number of efforts to reduce these types of costs [20–24].

In parathyroid surgery, most studies looking at cost savings have focused on the superiority of MIP over BNE. In addition to other potential benefits, it appears that MIP may be more cost-effective [5,14–16,25,26]. At least some of this economic advantage is attributable to the shorter operative time that MIP requires, at least in some surgeons' hands. Surgeons have investigated a number of technique modifications, aimed at further reducing ST in order to shorten OT.

However, research on mechanisms in parathyroid surgery designed to reduce NST, the times before incision (PIT) and after closure (PCT), is extremely limited. This is significant because up to 40–45% of total OT is NST. Anecdotally, this matched our experience, as we often felt that the PIT and PCT consumed as much time as the actual surgery itself.

One recent study did report on an initiative to reduce NST, specifically PIT, in parathyroidectomies and other endocrine surgeries. Clark et al. found that for these cases when attending surgeons arrived in the OR sooner after patient entry there was a significant shortening of the time to incision [27]. An earlier presence allows the attending to aid in positioning, instrument/supply selection, and other preparations. For parathyroidectomies, the mean PIT was 39 min when the attending surgeon entered the OR < 10 min after the patient and averaged 66 min when the attending arrived > 10 min after the patient. This time reduction translated to more than $1400 in savings per case.

This study was also designed to assess mechanisms to shorten NST. Our results show that both measures, preoperative insertion of a second PIV and utilization of MAC, significantly reduced NST.

Any parathyroidectomy technique that utilizes ioPTH assessment necessitates serial blood sampling. While PTH assays require a period of time to incubate, providing timely blood specimens is critical [28]. Any delay in obtaining blood can lead to an unnecessary lengthening of the surgery. Surgical teams use a number of techniques for obtaining blood — phlebotomy draws with a straight needle, phlebotomy draws with a butterfly needle, or draws through a PIV. Collecting specimens with any of these techniques can have problems, leading to delays. In our practice, on a number of occasions, procuring the baseline ioPTH specimen was challenging, resulting in extended PIT. Consequently, in our practice we incorporated routine placement of a second PIV into the preoperative regimen. This appeared to facilitate collection of the blood samples, particularly the baseline level. In cases in which a second PIV was placed preoperatively, the PIT was reduced by > 8 min per case, compared to cases in which patients had blood drawn by a different approach.

Prior studies have shown that performing parathyroid surgery with MAC and a regional nerve block is safe and this approach is widely utilized by select surgeons [29,30]. However, most of the studies in the literature on parathyroidectomy describe using general anesthesia during surgery. One potential benefit of the former approach is the shortening of OT. General anesthesia requires induction, intubation, and securing the endotracheal tube in place prior to incision, and its reversal also has prolonged post-closure time compared to MAC. In our study, we found that both PIT and PCT were significantly reduced in patients managed with MAC. Combined, PIT and PCT were > 12 min shorter on average in MAC cases. Prior studies have described the use of MAC with regional block in patients undergoing both MIP and BNE. In our cohort, 3 patients required BNE and no conversions were needed to general anesthesia.

Importantly, the 2 techniques assessed in this study can be widely applied in parathyroid surgery. Regardless of the precise surgical approach employed, if ioPTH monitoring is utilized, placement of second PIV can likely be beneficial. MAC can also be used in a range of parathyroidectomy techniques, including MIVAP [19]. In our series most cases with MAC were MIPs, but 3 patients did have BNE. Not all patients are candidates for MAC, but its use can be at least considered on a case-by-case basis.

Limitations of this study include its retrospective nature and the inherent bias introduced by analyzing data from a single surgeon at one institution. For example, the accumulating experience of the surgeon, anesthesia, and the OR staff may have impacted the different times measured. However, while experience may have contributed to improved times it is unlikely to explain completely the significant savings that were observed. Additionally, a complete analysis of the all the times and resources required for a case to be completed was not pursued. It is important, therefore, to acknowledge that time saved in the OR may have been the result of additional time/effort spent elsewhere (such as with placement of the second IV in the holding area).

## 5. Conclusion

In the current healthcare environment surgeons need to scrutinize time expenditures in the OR in an effort to possibly restrain costs. This study demonstrates the potential non-operative time savings that can be achieved in parathyroid surgery by utilizing MAC rather than general anesthesia and placing preoperatively 2 PIVs to facilitate ioPTH monitoring. Surgeons performing parathyroid surgery should consider adopting these methods to aid in reducing non-surgical OR times.

## Declaration of competing interest

Dr. Singer is a paid consultant of Medtronic, Jacksonville, Florida.

## References

[1] Rogers-Stevane J, Kauffman GL. A historical perspective on surgery of the thyroid and parathyroid glands. Otolaryngol Clin North Am 2008;41(6):1059–67. https://doi.org/10.1016/j.otc.2008.08.003.
[2] Laird AM, Libutti SK. Minimally invasive parathyroidectomy versus bilateral neck exploration for primary hyperparathyroidism. Surg Oncol Clin N Am 2016;25(1):103–18. https://doi.org/10.1016/j.soc.2015.08.012.
[3] Goldstein RE, Blevins L, Delbeke D, Martin WH. Effect of minimally invasive radioguided parathyroidectomy on efficacy, length of stay, and costs in the management of primary hyperparathyroidism. Ann Surg 2000;231(5):732–42.
[4] Bergenfelz A, Kanngiesser V, Zielke A, Nies C, Rothmund M. Conventional bilateral cervical exploration versus open minimally invasive parathyroidectomy under local anaesthesia for primary hyperparathyroidism. Br J Surg 2005;92(2):190–7. https://doi.org/10.1002/bjs.4814.
[5] Udelsman R, Lin Z, Donovan P. The superiority of minimally invasive parathyroidectomy based on 1650 consecutive patients with primary hyperparathyroidism. Ann Surg 2011;253(3):585–91. https://doi.org/10.1097/SLA.0b013e318208fed9.
[6] Slepavicius A, Beisa V, Janusonis V, Strupas K. Focused versus conventional parathyroidectomy for primary hyperparathyroidism: a prospective, randomized, blinded trial. Langenbecks Arch Surg 2008;393(5):659–66. https://doi.org/10.

1007/s00423-008-0408-1.

[7] Miccoli P, Berti P, Materazzi G, Massi M, Picone A, Minuto MN. Results of video-assisted parathyroidectomy: single institution's six-year experience. World J Surg 2004;28(12):1216–8. https://doi.org/10.1007/s00268-004-7638-3.

[8] Berti P, Materazzi G, Picone A, Miccoli P. Limits and drawbacks of video-assisted parathyroidectomy. Br J Surg 2003;90(6):743–7. https://doi.org/10.1002/bjs.4183.

[9] Henry J-F, Sebag F, Tamagnini P, Forman C, Silaghi H. Endoscopic parathyroid surgery: results of 365 consecutive procedures. World J Surg 2004;28(12):1219–23. https://doi.org/10.1007/s00268-004-7601-3.

[10] Gagner M. Endoscopic subtotal parathyroidectomy in patients with primary hyperparathyroidism. Br J Surg 1996;83(6):875.

[11] Rubello D, Piotto A, Casara D, Muzzio PC, Shapiro B, Pelizzo MR. Role of gamma probes in performing minimally invasive parathyroidectomy in patients with primary hyperparathyroidism: optimization of preoperative and intraoperative procedures. Eur J Endocrinol 2003;149(1):7–15.

[12] Farley DR. Technetium-99m 2-methoxyisobutyl isonitrile-scintigraphy: preoperative and intraoperative guidance for primary hyperparathyroidism. World J Surg 2004;28(12):1207–11. https://doi.org/10.1007/s00268-004-7639-2.

[13] Kay S, Godsell J, Edelmayer L, Terris DJ. Microinvasive parathyroidectomy: incremental improvement in minimally invasive parathyroid surgery. Laryngoscope 2017. https://doi.org/10.1002/lary.27026. December.

[14] Udelsman R. Six hundred fifty-six consecutive explorations for primary hyperparathyroidism. Ann Surg 2002;235(5):665–70. [discussion 670-672].

[15] Fahy BN, Bold RJ, Beckett L, Schneider PD. Modern parathyroid surgery: a cost-benefit analysis of localizing strategies. Arch Surg Chic Ill 1960 2002;137(8):917–22. [discussion 922-923].

[16] Lowney JK, Weber B, Johnson S, Doherty GM. Minimal incision parathyroidectomy: cure, cosmesis, and cost. World J Surg 2000;24(11):1442–5.

[17] Nelson CM, Victor NS. Rapid intraoperative parathyroid hormone assay in the surgical management of hyperparathyroidism. Perm J 2007;11(1):3–6.

[18] Vignali E, Picone A, Materazzi G, et al. A quick intraoperative parathyroid hormone assay in the surgical management of patients with primary hyperparathyroidism: a study of 206 consecutive cases. Eur J Endocrinol 2002;146(6):783–8.

[19] Miccoli P, Barellini L, Monchik JM, Rago R, Berti PF. Randomized clinical trial comparing regional and general anaesthesia in minimally invasive video-assisted parathyroidectomy. Br J Surg 2005;92(7):814–8. https://doi.org/10.1002/bjs.5048.

[20] Dyas AR, Lovell KM, Balentine CJ, et al. Reducing cost and improving operating room efficiency: examination of surgical instrument processing. J Surg Res 2018;229:15–9. https://doi.org/10.1016/j.jss.2018.03.038.

[21] Thiel CL, Fiorin Carvalho R, Hess L, et al. Minimal custom pack design and wide-awake hand surgery: reducing waste and spending in the orthopedic operating room. Hand N Y N 2017. https://doi.org/10.1177/1558944717743595. 1558944717743595.

[22] Tabib CH, Bahler CD, Hardacker TJ, Ball KM, Sundaram CP. Reducing operating room costs through real-time cost information feedback: a pilot study. J Endourol 2015;29(8):963–8. https://doi.org/10.1089/end.2014.0858.

[23] Zeybek B, Oge T, Kılıç CH, Borahay MA, Kılıç GS. A financial analysis of operating room charges for robot-assisted gynaecologic surgery: efficiency strategies in the operating room for reducing the costs. J Turk Ger Gynecol Assoc 2014;15(1):25–9. https://doi.org/10.5152/jtgga.jtgga.2014.79989.

[24] Clark N, Schneider DF, Vrabec S, Bauer PS, Chen H, Sippel RS. Increased efficiency of endocrine procedures performed in an ambulatory operating room. J Surg Res 2013;184(1):200–3. https://doi.org/10.1016/j.jss.2013.04.038.

[25] Zanocco K, Heller M, Sturgeon C. Cost-effectiveness of parathyroidectomy for primary hyperparathyroidism. Endocr Pract Off J Am Coll Endocrinol Am Assoc Clin Endocrinol 2011;17(Suppl. 1):69–74. https://doi.org/10.4158/EP10311.RA.

[26] Harari A, Allendorf J, Shifrin A, DiGorgi M, Inabnet WB. Negative preoperative localization leads to greater resource use in the era of minimally invasive parathyroidectomy. Am J Surg 2009;197(6):769–73. https://doi.org/10.1016/j.amjsurg.2008.04.023.

[27] Clark A, Dackiw AP, White WD, et al. Early endocrine attending surgeon presence increases operating room efficiency. J Surg Res 2016;205(2):272–8. https://doi.org/10.1016/j.jss.2016.06.093.

[28] Garbutt L, Sigvaldason H, Sharaf Eldin MHT, Dembinski T, Nason RW, Pathak KA. What is the most appropriate intraoperative baseline parathormone? A prospective cohort study. Int J Surg Lond Engl 2016;25:49–53. https://doi.org/10.1016/j.ijsu.2015.11.044.

[29] Ditkoff BA, Chabot J, Feind C, Lo Gerfo P. Parathyroid surgery using monitored anesthesia care as an alternative to general anesthesia. Am J Surg 1996;172(6):698–700.

[30] Lebastchi AH, Donovan PI, Udelsman R. Paradigm shift in the surgical management of multigland parathyroid hyperplasia: an individualized approach. JAMA Surg 2014;149(11):1133–7. https://doi.org/10.1001/jamasurg.2014.1296.