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Original Research

Application of carbon nanoparticles accelerates the rapid recovery of parathyroid function during thyroid carcinoma surgery with central lymph node dissection: A retrospective cohort study

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HIGHLIGHTS

- In this study, carbon nanoparticles was associated with more central lymph nodes dissected and less parathyroid glands removed incidentally.
- The follow-up outcomes showed that Carbon nanoparticles had played a key role in promoting rapid recovery of parathyroid function during thyroid carcinoma surgery with central lymph node dissection.
- It was suggested to routinely use carbon nanoparticles during thyroid carcinoma surgery combined with central lymph node dissection.

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ABSTRACT

Background and Objectives: The aim of this study was to evaluate the efficacy of carbon nanoparticles in identifying lymph nodes and promoting parathyroid gland function recovery after thyroid carcinoma surgery along with central lymph node dissection.
Methods: A total of 231 patients who underwent thyroid carcinoma surgery combined with central lymph node dissection were divided into two groups: the CN group (intraoperative carbon nanoparticles injections) and the control group (no injection). Datas were collected respectively on the pre-operative, 1st, 7th and 30th postoperative days and monthly thereafter. While the pathological results (e.g. amount of incidental removed parathyroid glands and lymph nodes dissected), complications (e.g. rates of vocal cord paralysis, the neuromuscular symptoms, hypocalcemia and hypoparathyroidism), as well as follow-up outcomes of the serum Ca2+ and PTH levels were gathered and measured to be included in.
Results: In regard to the results of the pathological tests, the control group had a relatively higher incidence of incidental parathyroidectomy when compared to the CN group ($P < 0.05$). The mean number of central lymph nodes dissected was rather higher in the CN group than that of the control group ($P < 0.05$).With respect to the follow-up results, the CN group had an earlier and faster recovery of serum PTH levels as compared to the control group ($P < 0.05$). The serum PTH levels of the CN group were apparently higher than that of the control group at the first week and month postoperatively ($P < 0.05$). No significant differences were found in rates of long-term postoperative complications between the two groups ($P > 0.05$).
Conclusion: Carbon nanoparticles play a key role in accurately identifying lymph nodes, reducing mistaken excision of parathyroid glands, accelerating rapid recovery of parathyroid function during thyroid carcinoma surgery with central lymph node dissection, without increasing the probability of postoperative complications.

1. Introduction

It is particularly notorious that central lymph node dissection (CLND) is commonly performed among patients with papillary

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thyroid carcinoma. However, recurrent laryngeal nerve injury and hypoparathyroidism are the two main concerns when it comes to CLND. With the routine exposure of recurrent laryngeal nerve and development of surgical techniques, the incidence of recurrent laryngeal nerve injury is dramatically decreasing. On the contrary, hypoparathyroidism still occurs frequently, because of the expansion of the scope of operation and incidental removal of parathyroid glands (PGs) other than lymph nodes [1]. The transient hypocalcemia incidence rate is 1.6%–50%, and the permanent hypocalcemia incidence rate is 1.5%–4% [2–5]. Therefore, the problem that needs to be solved is how to avoid incidental removal of PGs and devascularization of the PGs.

Long-term follow up data in previous studies demonstrated that autotransplantation cannot recover PG activity to the preoperative levels [6,7]. Careful preservation of PGs in situ especially meticulous capsular dissection without jeopardizing PG blood supply is advocated to accelerate the recovery of PGs function, but usually not technically possible by conventional total thyroidectomy with CLND. Several relevant Chinese studies had confirmed that CNs could help reduce the prevalence of PGs injury after thyroid surgery combined with CLND [8–11]. Nonetheless, these studies mainly put emphasis on short-term follow-up, while the reports concerns long-term outcomes are rather rare [12].

Therefore, the study of this paper turns to focus on the efficacy of CNs in long-term PGs function recovery after thyroid carcinoma surgery combined CLND.

2. Materials and methods

2.1. Patients and perioperative management

This study was approved by the Clinical Ethics Committee of Changzheng Hospital. From January 2013 to January 2014, 285 patients who preoperatively diagnosed as micropapillary carcinoma based on ultrasound-guided fine needle aspiration cytology had undergone thyroid carcinoma surgery with CLND. Among them, those patients were excluded when they met one or more of the following terms: (1) a history of neck surgery or radiotherapy; (2) concomitant Grave's disease, (3) preoperative hypoparathyroidism or hypocalcemia; and (4) the inability to comply with the follow-up protocol. Overall, 231 patients were included in this study. According to the surgical protocol, the patients were divided into the CN group (intraoperative CN injections) and the control group (no injection). Their age ranges from 19 to 71 years old (median, 44 years). All patients were evaluated preoperatively with the adoption of ultra-sonography and fine-needle aspiration cytology. All patients took preoperative direct laryngoscopy for the sake of assessing vocal cord motility. The advantages and disadvantages of CNs were fully informed before surgery; it was up to the patients' free will when it comes to choosing or forsaking CNs.

2.2. Outcome measures

The primary outcome measures were pathological results (e.g. amount of incidental removed PGs, central and lateral lymph nodes dissected) follow-up results (e.g. recovery of serum calcium [Ca^{2+}] and parathyroid hormone [PTH] levels). The secondary end-points were the rates of complications (e.g. rate of vocal cord paralysis, the neuromuscular symptoms, hypocalcemia and hypoparathyroidism), in-hospital postoperative hormonal assay, and lymph node metastases.

2.3. Definition

"Hypoparathyroidism" was defined as a condition in which calcium or vitamin D supplementation was required to maintain normocalcemia and the serum intact PTH concentration was less than 15 pg/mL (normal values, 15–65 pg/mL). Hypocalcemia happens when serum Ca^{2+} concentration was less than 1.9 mmol/L. If clinical symptomatic hypocalcemia returned to normal levels within 6 months, hypoparathyroidism would be defined as "transient"; it was otherwise labeled as "permanent".

2.4. Surgical procedures

After dissecting the strap muscles in the midline, the anterior capsule of thyroid would be carefully dissociated and the abnormal lobe would come to light. To reduce the risk of destroying the surrounding thyroid lymphatic network, the dorsal tissue of thyroid was left temporarily unseparated. Then, CN injection to the thyroid lobe should be carried out. At the meantime, a 5 ml syringe was required. The CN puncture site was located in the middle of anterior capsule of thyroid lobe. (Fig. 1). CNs suspension was injected into the thyroid gland thereafter with 0.1–0.2 mL administered per lobe. After injection, the needle puncture site would be pressed with gauze for 2–3 min. As a result, the thyroid, surrounding lymph tissue and level VI of lymph nodes were stained black. PGs were then visibly different from the thyroid gland and lymph nodes in the central compartment (Fig. 2).

All patients had completed abnormal thyroid lobes and isthmus resection. After intraoperative frozen sections confirmed the diagnosis of papillary thyroid carcinoma, lymph node clearance would be carried out in the central zone or lateral zone. Central lymph nodes dissected included the prelaryngeal, pretracheal, and paratracheal lymph nodes. Ipsilateral lymph nodes dissection or bilateral lymph nodes dissection was determined by the size and location of tumor. If patients need to receive radioactive iodine treatment, total thyroidectomy should be performed. The posterior branch of superior thyroid artery and a branch of inferior thyroid artery should be preserved to avoid damages toward the blood supply of the PGs.

2.5. Postoperative follow-ups

Postoperative evaluation of all patients included assessments of serum Ca2+ and PTH levels, and pathological characteristics (e.g. number of removed PGs and lymph nodes). Ca2+ and PTH levels were tested preoperatively as well as on the 1st and 7th days respectively after operation. All patients underwent a complete

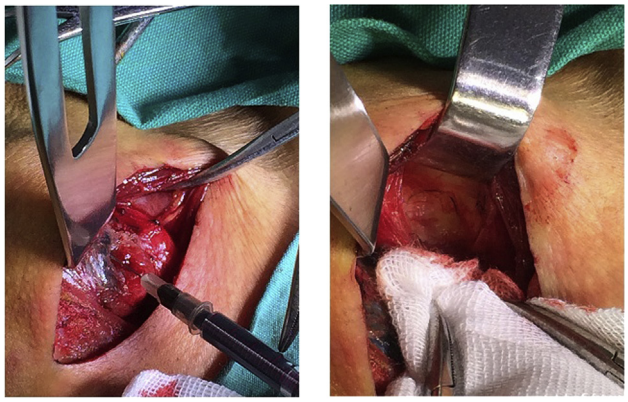

Fig. 1. Carbon nanoparticles were injected into thyroid gland.