A short review of basic head and neck interventional procedures in a general radiology department

H.Y. Yuen, Y.Y.P. Lee, K. Bhatia, A.T. Ahuja

Department of Imaging and Interventional Radiology, The Chinese University of Hong Kong, Prince of Wales Hospital, 30–32 Ngan Shing Street, Shatin, New Territories, Hong Kong SAR

Corresponding address: A.T. Ahuja, Department of Imaging and Interventional Radiology, The Chinese University of Hong Kong, Prince of Wales Hospital, 30–32, Ngan Shing Street, Shatin, New Territories, Hong Kong SAR

Email: aniltahuja@cuhk.edu.hk

Date accepted for publication 17 September 2013

Abstract

Image-guided interventional procedures provide a safe way to diagnose and treat a variety of head and neck abnormalities. The procedure time is usually short, and most procedures can be performed on an outpatient basis. Knowledge about strengths and weaknesses, efficacy, potential complications, and pitfalls of these procedures allows the best treatment to be chosen for a particular lesion type. This review discusses some of the commonly performed interventional radiology procedures in a general radiology department in the management of patients with neoplastic diseases in the head and neck region.

Keywords: Head and neck; cancer; interventional procedure; biopsy; ethanol ablation; vocal cord injection; radiofrequency ablation.

Introduction

As in most areas of medicine, radiology plays a pivotal role in head and neck surgery and oncology. This review discusses some of the commonly performed interventional radiology procedures in a general radiology department in the management of patients with neoplastic diseases in the head and neck region.

Ultrasound-guided biopsy

The initial step in the work-up of any neoplastic disease is to establish the diagnosis. While mucosal lesions in the upper aerodigestive tract can be accessed and biopsied by endoscopy, many malignant tumors present as mass lesions in the neck, which may or may not be palpable.

Modern high-resolution ultrasound is ideal in the initial assessment of most neck lesions, and can determine their nature and delineate their location and extent, with the exception of deep-seated lesions[1]. Although ultrasound is sensitive in identifying the abnormality, it may lack specificity. This shortcoming can be overcome by combining ultrasound with fine-needle aspiration cytology (FNAC). FNAC performed under ultrasound guidance therefore complements diagnostic ultrasound in the evaluation of head and neck lesions. It is a readily available, inexpensive, relatively noninvasive, well tolerated, and rapid outpatient procedure with reported diagnostic accuracy in malignant lymphadenopathy exceeding 90%[2]. However, often there are still nondiagnostic FNAC samples (due to suboptimal smear preparation, scanty aspirate, or heavy blood contamination) and incomplete classification, especially in cases of lymphoma. The nondiagnostic rate for FNAC in head and neck lesions ranges from 10% to 30%[3–6], and in part depends on the cytologist’s expertise. Repeating the FNAC may not always provide definitive diagnosis, while increasing patients’ anxiety and frustration. As such, core-needle biopsy under ultrasound guidance is a valuable alternative. In fact, some institutes prefer core-needle biopsy as the first approach to tissue sampling.

Core biopsy needles fall into 2 major categories: side-cutting and end-cutting needles. Side-cutting needles consist of the outer cutting shaft and the inner stylet with a specimen notch (Fig. 1). With the needle tip positioned at the target tissue edge, the inner stylet is advanced into the target tissue, which will partly prolapse into the specimen notch. The specimen is obtained by advancing the outer cutting shaft to resheath the inner stylet and cut out the specimen core. The major drawback of side-cutting
needles is that part of the outer shaft and the stylet distal to the specimen notch may have to extend beyond the target to place the notch at the optimal position, such that there is increased risk of injury to adjacent structures. This is a particular concern for biopsy of neck lesions, which are frequently in close proximity to major vessels. Moreover, the amount of sample retrieved in each pass is determined by the size of the specimen notch, and often multiple passes may be required to obtain adequate tissue samples, especially when microbiology or biochemical tests are needed in addition to histopathology.

End-cutting needles comprise an inner stylet and an outer trocar (Fig. 2). The needle tip is positioned at the target area within the sampling tissue, and a syringe is attached via a connection tube to the trocar after removal of the inner stylet. With suction applied by the syringe, the trocar is moved to-and-fro and rotated to retrieve the sample specimen. Specimen disposal from the needle is achieved by reintroduction of the trocar or saline flush into a specimen bottle. The technique of using the end-cutting needle is similar to that for the use of fine needles for aspiration cytology. There are different designs of the configuration of the tip of the end-cutting needles, and this example shows the serrated cutting end of the Franseen needle.

Core biopsy yields large tissue samples with preserved architecture which, together with immunohistochemical stains, provide precise histopathologic diagnosis. Published results show excellent performance of side-cutting needles for head and neck lesions, widely perceived as a safe and effective technique for biopsy of head and neck lesions\[8–12\] including lymph nodes\[13,14\], salivary glands\[15\], and thyroid\[16–19\]. Sensitivity, specificity, and accuracy of 97.9%, 99.1%, and 97.9%, respectively, were reported by Kim et al.\[13\] for ultrasound-guided core-needle biopsy of cervical lymphadenopathy in patients with no known malignancy, with no procedure-related complications. Screaton et al.\[14\] also reported sensitivity, specificity, and accuracy of 98.1%, 100%, and 98.7%, respectively, for ultrasound-guided core biopsies of cervicofacial lymphadenopathy in the differentiation of benign from malignant lymphadenopathy. For lymphoma, sensitivity of 98.5%, specificity of 100%, and accuracy of 98.7% in the differentiation of lymphoma from reactive lymphadenopathy\[14\], and 80% sufficiency in histological subclassification to guide management without the need for surgical biopsy have been reported\[14\]. Buckland et al.\[15\] reported a short series of ultrasound-guided cutting-needle biopsy of parotid lesions in 16 patients. The biopsy yielded diagnostic specimens in all patients and was diagnostic in 13 patients whose FNAC were inconclusive. Accuracy of 100% was observed in 7 patients who were subsequently operated on, and 9 patients avoided unnecessary surgery. A modified coaxial technique for simultaneous FNAC and biopsy of thyroid nodules was proposed by Strauss et al.\[18\] in cases when FNAC alone was insufficient. Ultrasound-guided core-needle biopsy was advocated by Kwak et al.\[19\] as a safe and accurate method for the diagnosis of thyroid lymphoma, and may suitably replace diagnostic thyroid surgery.

To our knowledge, there are no published results on the performance of end-cutting needles for head and neck
lesions, and thus direct comparison between the 2 needle types is not feasible. However, our own experience\cite{20} in using the Franseen trephine type needle with the serrated stylet tip showed it to be safe and of high yield in terms of adequacy and accuracy. The risk of injury to normal structures occult on ultrasound, such as the facial nerve within the parotid gland during needle advancement with the trocar in situ, is minimal and no greater than that of FNAC. No complication of seeding along the biopsy tract, significant hemorrhage, or scar induction were encountered, presumably because of the small caliber of the needles used and the minimal (only one in most of the cases) number of needle passes required. At our institute, the use of the Franseen needle biopsy extends to biopsy of deep-seated lesions via the intraoral approach under ultrasound guidance\cite{21}. The use of the Franseen needle, with its lower risk of injury to adjacent vasculature and high yield in a single pass, is ideal for this purpose. 18-Gauge or 20-gauge Franseen needles usually suffice for biopsy of lymphadenopathy and salivary glands. 22-Gauge Franseen needles are optimal for biopsy of thyroid lesions, small lesions, and deep-seated lesions via the intraoral approach.

Percutaneous ethanol injection ablation of neck nodal metastases from papillary thyroid carcinoma

Interventional radiology also contributes to the treatment of malignant disease in the neck. One of the common applications is to perform ultrasound-guided percutaneous ethanol ablation of neck nodal metastases from papillary thyroid carcinoma.

Total thyroidectomy with excision of affected regional nodes is the most common primary treatment for papillary thyroid carcinoma. It is often complemented by ablation of remnants with radioactive iodine-131. However, on follow-up new or previously undiagnosed lymph node metastases may be identified in many patients with papillary thyroid carcinoma.

For recurrent papillary thyroid carcinoma, radiiodine therapy is often of limited value. In view of the indolent course of the disease and the difficulty of subsequent surgery, there is a need for a less invasive approach than repeated surgical exploration for treating patients with limited nodal metastases.

Percutaneous ethanol injection is a well-established treatment modality in other body parts, including hepatocellular carcinoma (HCC)\cite{22}, benign parathyroid adenomas, hyperfunctioning thyroid nodules\cite{23}, and cystic thyroid nodules\cite{24}. Percutaneous ethanol injection treatment of limited cervical lymph node metastases from papillary thyroid carcinoma was first reported by Lewis et al.\cite{25}. Five or fewer involved lymph nodes that are amenable to percutaneous ethanol injection was proposed as the selection criteria, and patients were either poor surgical candidates expressing preference for no further surgery or were unresponsive to previous radioiodine therapy.

The technique is relatively straightforward. Under ultrasound guidance, each node is punctured and injected at multiple sites for complete treatment. Alcohol 99.5% is used, and the volume injected depends on the lesion size. Injection is stopped when the lesion is completely filled or when the injected ethanol starts to diffuse along the needle track toward the surrounding soft tissues. The deepest portion of node is treated first; the needle is then repositioned and injection is repeated until the entire node is adequately treated (Fig. 3). Care must be taken to avoid diffusion of ethanol along the needle track into surrounding cervical soft tissues. At least 2 treatment sessions are required for each patient, because the lesion is usually mostly solid before the first injection and the injected ethanol tends to diffuse back along the needle track before the lesion is completely treated. The lesion then becomes more necrotic a few weeks later, and a second injection usually can completely fill up the lesion.

Routine clinical and sonographic follow-up every 6–8 weeks is then arranged for each patient. The end point is achieved when the node on follow-up has disappeared or decreased in size, and there is no residual evidence of perfusion on power Doppler. A small percentage of patients may experience transient hoarseness or minor and transient pain, but major complication such as nerve damage is rare.

Advantages of percutaneous ethanol injection (PEI) include that it is far less invasive than neck exploration, can be repeated multiple times without increased technical difficulty, is of low cost with little or no morbidity, and can be performed as an outpatient procedure. It is therefore an inexpensive, effective, essentially risk-free alternative for patients who might otherwise be considered for watchful waiting.

Repeated exploration and radiiodine therapy are reserved as appropriate treatments for patients with widely metastatic disease and for those with a more aggressive form of papillary thyroid carcinoma.

Ultrasound-guided vocal cord injection for unilateral vocal cord paralysis

Ultrasound is also useful in guiding procedures aiming to treat complications of malignant disease. One recently introduced application is ultrasound-guided vocal cord injection for unilateral vocal cord paralysis\cite{26}.

Vocal cord paralysis caused by tumor infiltration of the recurrent laryngeal nerve is a common complication in patients suffering from neck and mediastinal malignancies. The approach to treatment of symptomatic unilateral vocal cord palsy is to attain medialization of the paralyzed vocal cord. The glottic competence on phonation and swallowing can be restored by bringing the paralyzed cord to midline or near-midline position, with only one functional contralateral vocal cord.
Traditional surgical treatment includes vocal cord injection and laryngeal framework surgery. Transcutaneous vocal cord injection is usually the preferred treatment because of its relative simplicity. The needle can be inserted through the cricothyroid membrane toward the undersurface of the vocal cord\textsuperscript{[27]}, or through the thyrohyoid notch to access the endolaryngeal and then the vocal cord under endoscopic guidance\textsuperscript{[28]}. This action allows direct visualization to guide needle placement for injection. However, at times the alterations/variations in anatomy may not allow needle entry.

Alternatively the needle can be inserted directly through the thyroid cartilage to enter the vocal fold. This transcortilaginous approach avoids any anatomic constraint to access the vocal cord except for heavily calcified/ossified thyroid cartilage. However, it is a submucosal approach and is mostly a blind procedure, which at times can be difficult for accurate needle positioning, and is particularly problematic in patients with thick neck soft tissues in whom external judgment of the level of the vocal cords is a daunting task.

Ultrasound guidance is a useful adjunct to this procedure\textsuperscript{[26]}. The false vocal cords and the vocal ligament (free edge of the true cord) appear hyperechoic because of their high fibrous content, while the true vocal cords appear hypoechoic because of their high muscle content\textsuperscript{[29,C15131]}. The level of vocal cords is approximately at the midpoint between the thyroid notch and the lower border of thyroid cartilage at the midline. The sonographic identification of the vocal fold can be further facilitated by reference to the phasic vocal cord movement (of the normal side) during respiration. As such, ultrasound can be used for real-time guidance of needle entry and direction of insertion to attain the optimal position for vocal cord injection (Fig. 4). The needle entry site is paramedian, with angulation targeting the...
center of the vocalis muscle. A number of biocompatible materials can be used for injection. We have used Radiesse or Restylane. Radiesse is an injectable implant that contains synthetic calcium hydroxyapatite microspheres (25–45 μm) suspended in an aqueous gel carrier. Restylane (small particle-size hyaluronic acid) contains animal- or bacterial-derived variations of the naturally occurring extracellular glycosaminoglycan present in various human tissues such as the vocal cord lamina propria. The location and adequacy of vocal cord medialization may also be assessed during injection by ultrasound [26].

Ultrasound-guided vocal fold injection for unilateral vocal cord paralysis helps patients with cancer to regain the glottic competence on phonation and swallowing, thereby mitigating the problems of hoarseness and aspiration.

Radiofrequency ablation

In 1975, Onofrio[32] reported on fluoroscopic-guided radiofrequency ablation (RFA) rhizotomy for the treatment of trigeminal neuralgia in 140 patients, the first report on percutaneous RFA for head and neck disease. At present, percutaneous RFA is an established treatment option for various head and neck diseases. This section focuses on the RFA procedures predominantly performed in radiology departments, particularly using ultrasound guidance.

In the late 1990s, Solbiati et al.[33] and Dupuy et al.[34] reported on percutaneous RFA for local-regional control of recurrent well-differentiated thyroid carcinoma (DTC). Between 2001 and 2011, multiple studies reported successful disease control for local-regional recurrent DTC[35–38] and benign thyroid nodules[39–49] by ultrasound-guided percutaneous RFA.

Computed tomography (CT)-guided percutaneous RFA for head and neck diseases has also been used for local control of recurrent adenocystic carcinoma by Bui et al.[50] in 2002, and in a series of patients with advanced head and neck cancer by Brook et al.[51] in 2008 and Owen et al.[52] in 2011. However, its reported use and application are less than ultrasound-guided guided RFA procedures.

Principles of RFA

RFA works by sending an oscillating current to a target lesion via an active tip. The current returns by a large-area dispersive electrode that adheres to another part of the body. A high field density is created around the needle tip because of its relatively small area, and micromovements of tissue ions are induced by the oscillating current, which in turn creates frictional heat. When the frictional heat reaches a cytotoxic threshold (threshold temperature usually >60°C), thermal ablation is achieved. The thermal energy is dissipated by conduction to areas adjacent to the active tip, inducing further coagulation necrosis or reversible hyperthermia in farther tissues, depending on the temperatures attained[53] (Fig. 5).

The time required to induce irreversible cellular damage is shorter at a higher temperature. At tissue temperature of 50–52°C, cell death occurs in 4–6 minutes, whereas at 60–100°C, cellular damage occurs almost instantly. Further increase in tissue temperature to 100–110°C results in tissue vaporization[54].

Preablation assessment

Imaging

CT or ultrasound guidance should be performed before treatment for documentation of lesion size, volume, and characteristics. Fibrosis and calcification are an intrinsic hindrance to thermal ablation[53] while for predominantly cystic lesions, ethanol ablation is a good alternative[55].

FNAC

FNAC should be done under image guidance to ensure that the sample is taken from a representative area. For malignant lesions, a positive FNAC result is generally considered adequate, whereas 2 FNACs obtained on 2 separate occasions are required before treating benign thyroid nodules.

Symptoms and cosmetic concerns

These aspects could be documented by the help of a visual analog scale or scoring system for ease of comparison during follow-up[54].
Laboratory test

In general, a complete blood count and coagulation profile are obtained. For the treatment of thyroid-related lesions, thyroid function, serum thyroglobulin, and antithyroglobulin antibody are measured [37].

Devices

Current output from a radiofrequency (RF) generator is delivered to the lesion via an RF electrode. Two types of RF electrodes have been used. A multipronged expandable electrode (14-gauge, 10 cm long with 4–9 prongs expandable to 3.5–4.0 cm) was used by Deandrea et al. and Spiezia et al. [40,43] for their treatment of benign thyroid nodules, whereas a single, straight RF electrode (17–18-gauge, active tip 0.5–2 cm) (Fig. 6) was used in most other studies treating benign thyroid nodules or malignant head and neck cancer [35–39,41,42,44–49]. A straight electrode is more popular probably because of its smaller needle bore and easier manipulation for complete lesion ablation [54]. An internal cooling system, to prevent tissue charring and improve RF energy dissipation, is incorporated in most of the current straight electrodes. The radius of thermocoagulation is reported to be increased from 8 mm to 10–12 mm when an internal cooling system is incorporated [35,36].

Procedure

For ultrasound-guided RFA, it is advisable to have venous access before the start of the procedure to prepare for any complication that may require resuscitation, although such a condition has never been reported. Local anesthesia is adequate for pain control. Premedication is avoided in most reported studies, as continuous verbal communication with patient serves as an important guide to identify any injury to the recurrent laryngeal nerve [37,41,42]. Local anesthesia is used for infiltration of the skin puncture site and around the target lesion. A small (3–4 mm) skin incision was made by Deandrea et al. [40], catering for the use of a larger-bore multipronged electrode, whereas studies that used straight electrodes did not require a skin incision [35–39,41,42,44–49].

Electrodes are introduced in a plane such that the whole needle tract and the needle tip are visualized on ultrasound. The active tip is placed to avoid injury of structures in the danger triangle deep to the medial aspect of the thyroid gland, where the recurrent laryngeal nerve and/or esophagus are expected (Fig. 7). The transisthmic approach is therefore advocated for the treatment of thyroid lesions [54] (Fig. 7). Transient echogenic change during treatment is thought to represent coagulative necrosis and tissue vaporization, and serves as an indicator of successful thermocoagulation. The echogenic area generated immediately obscures posterior structures (Fig. 8) and, for larger lesions, the electrode tip has to be repositioned a few times for complete treatment [35–37,39,41,42]. It is therefore recommended to ablate lesions from deep to

*Figure 5* Thermal lesion formed around active tip of RF electrode.

*Figure 6* (A) Internally cooled RF electrode for thyroid lesion: 7 cm long, 18-gauge (Apro Korea, CoATherm Ice). (B) Close-up view of active tips: 5 mm, 7 mm, and 10 mm.
superficial and from remote to close. Based on the above concept, Baek et al. proposed a moving shot technique for the treatment of larger thyroid lesions[37,41,42,44,45,49]. Ablation begins at a lower current, such as 30 W for 1-cm active tip or 50 W for a 1.5-cm active tip. If a transient hyperechoic zone does not form within 5–10 s, stepwise increment of power by 5–10 W is adopted up to a maximum of 100–110 W. Complete ablation is indicated by complete echogenic change of lesions after RFA.

CT-guided RFA is done under general anesthesia and, less often, conscious sedation[50,52]. It requires close monitoring by telemetry and continuous pulse oximetry. Vital signs should be closely recorded.

**Monitoring and follow-up**

Patients should be monitored for an hour after the procedure with light compression applied to the site of treatment. Severe neck pain or discomfort is managed with oral or intravenous analgesics[54].

Clinical symptoms, cosmetic concern, serum thyroglobulin level, thyroid function, and imaging appearances are monitored on follow-up. On ultrasound, treatment response is seen as reduction in size, and reduction/absence of intranodular vascularity if previously present. Progressive involution should be expected in the first few months to up to a year. Enlargement of the nodule after initial shrinkage should raise suspicion for recurrence, and an image-guided FNAC should be performed[35,37].

**Efficacy**

Ultrasound-guided RFA is predominantly used for local control of recurrent DTC (Table 1)[35–38]. Surgery remains the gold standard for the treatment of thyroid carcinoma and nodal metastasis.

RFA has been shown to be a safe and effective alternative for the treatment of cervical recurrence that is not suitable for surgery. RFA results in significant reduction in size and symptomatic improvement, with a low local recurrence rate if the lesions are completely ablated. The serum thyroglobulin level is generally reduced[37] but is more variable, as there may be other confounding factors such as distant metastasis.

Baek et al.[37] and Lewis et al.[25] suggested that RFA is superior to ethanol ablation for DTC recurrence, since it provides better disease control with fewer treatment sessions. Monchik et al.[36] advocate RFA for lesions
larger than 1 cm, and ethanol injection for lesions smaller than 10 mm or in close proximity to nerves.

CT-guided RFA in patients with incurable head and neck cancer, who have failed standard curative treatment, has been shown to be an effective treatment alternative that addresses the challenges of local control and quality of life (Table 2) [50–52].

Complications

Ultrasound-guided RFA

For ultrasound-guided RFA the complication rate is low, with hoarseness of voice being the most significant sequela. Most patients experience transient pain and heat sensation during RFA. This is usually well tolerated, and is reduced by lowering or turning off the power for a few seconds. Lower neck swelling and local discomfort are common [35,38,45] but usually self-limiting, and resolve within 1–2 weeks.

Hematoma and skin burn may occur along the treatment tract. Hematoma is usually a result of mechanical injury rather than thermal injury. If a hematoma is large, RFA should be deferred. Skin burn was reported in 2 patients treated for recurrent DTC [35,38] and in a few patients treated for benign thyroid nodules [39]. All occurred at the puncture site, resulting from a protruding active tip from a superficially located lesion, and all resolved within 2 weeks using topical ointments.

Important structures close to the thyroid gland include the recurrent laryngeal nerve, the esophagus, and the trachea. Recurrent laryngeal nerve palsy is usually detected during or immediately after the procedure as hoarseness of voice. Recovery usually occurs within 3 months, but residual dysphonia tends to be permanent [35,37–39,42,45]. If the target lesion is close to the recurrent laryngeal nerve, injection of 5% dextrose in water solution [36] or normal saline [54] between them may help in preventing nerve injury. If voice change occurs during the procedure, the ablation should be stopped immediately [45,54]. Heat irritation of the trachea results in coughing, and RFA should be stopped. To date, no permanent injury to the trachea or esophagus has been reported. Carotid blowout, procedure-related death, abscess, or infection has not been reported, but such possibilities should be kept in mind.

CT-guided RFA

Major complication rates of 11% and 14% were reported by Brook et al. [51] and Owen et al. [52], respectively. In both series, complications consisted of carotid blowout and stroke, with one patient dying as a result of carotid blowout. Retrospective analysis of intraprocedural CT scans by Brook et al. [51] revealed that the retractable electrodes were within 1 cm of the carotid artery during ablation in these cases.

The Task Force Committee of the Korean Society of Thyroid Radiology has published recommendations for the optimal use of RFA for benign thyroid nodules and recurrent thyroid cancers, based on literature review, multicenter studies, and expert consensus [56]. Indications for RFA of benign thyroid nodules include symptomatic

Table 1 Results of ultrasound-guided RFA in locoregional recurrence from differentiated thyroid cancer

|                     | Dupuy et al., 2001 [35] | Monchik et al., 2006 [36] | Baek et al., 2011 [37] | Park et al., 2011 [38] |
|---------------------|-------------------------|---------------------------|------------------------|------------------------|
| No. of patients     | 8                       | 16                        | 10                     | 11                     |
| No. of lesions      | 11                      | 23                        | 12                     | 16                     |
| Follow-up months, range (mean) | 6–26 (10.3) | 10–68 (40.7) | 16–31 (23 ± 5.5) | 1–14 (6) |
| Local recurrence    | 2                       | 2                         | 1                      | 2                      |
| New recurrence in the neck | 2                     | 3                         | 2                      | Not available |
| Size reduction (mm) | 24–18 mm                | –                         | 13.8 ± 7 to 3.3 ± 9.9 mm | –                     |
| Volume reduction    | –                       | 95% for lymph nodes       | 41–400%               | 9.4–96.8%              |

Table 2 Results of CT-guided percutaneous RFA in advanced head and neck cancer

|                     | Bui and Dupuy, 2002 [50] | Brook et al., 2008 [51] | Owen et al., 2011 [52] |
|---------------------|--------------------------|-------------------------|------------------------|
| No. of patients     | 1                        | 14                      | 21                     |
| No. of lesions      | 1                        | 27                      | 21                     |
| Lesion response     | 70% necrosis             | Yes (by RECIST criteria)| Yes (by RECIST criteria) |
| Quality of life     | Ear pain and facial paralysis resolved before mortality from pulmonary metastasis | Improved in 67% (4/6 patients) by University of Washington quality of life scores | Improved (by University of Washington quality of life scores) |
| Complications       | 0                        | 3 (11%)                 | 3 (14%)                |
| Carotid blowout     | 0                        | 1 (with death)          | 1                      |
| Stroke              | 0                        | 2                       | 2                      |

RECIST, Response Evaluation Criteria in Solid Tumors.
nodules, nodules causing cosmetic problems, and autonomously functioning thyroid nodules (AFTN) causing thyrotoxicosis. RFA may be used in patients with recurrent thyroid cancers in the surgical bed or lymph nodes, those who are at high surgical risk, or those who decline further surgery.

Conclusion

Image-guided interventional procedures provide a safe way to diagnose and treat a variety of head and neck abnormalities. The procedure time is usually short, and most procedures can be performed on an outpatient basis. Knowledge about strengths and weaknesses, efficacy, potential complications, and pitfalls of these procedures allows the best treatment to be chosen for a particular lesion type. With close collaboration with clinical colleagues, innovative treatment for a variety of lesions can be developed by head and neck interventional radiologists.

Acknowledgements

The authors are grateful to Dr Woojin Cho, M.D., Chief of Thyroid, Head and Neck Ultrasound Center, DAIN Ear Nose Throat Hospital, Seoul, Korea, for his contribution to the figures in this article.

Conflict of interest

The authors declare that they have no conflicts of interest.

References

[1] Adeyemo WL, Ogunlewe MO, Ladeinde AL. Ultrasound as a diagnostic aid in head and neck lesions. Niger Postgrad Med J 2006; 13: 147–152.
[2] Kline TS, Kannam V, Kline IK. Lymphadenopathy and aspiration biopsy cytology: review of 376 superficial nodes. Cancer 1984; 54: 1076–1081.
[3] Schelkun P, Grundy W. Fine-needle aspiration biopsy of head and neck lesions. J Oral Maxillofac Surg 1991; 49: 262–267.
[4] Chow LS, Gharib H, Goeliner JR, Van Heerden JA. Non-diagnostic thyroid fine-needle aspiration cytology: management dilemmas. Thyroid 2001; 11: 1147–1151.
[5] Alexander EK, Heering JP, Benson CB, et al. Assessment of nondiagnostic ultrasound-guided fine needle aspirations of thyroid nodules. J Clin Endocrinol Metab 2002; 87: 4924–4927.
[6] Rakshman M, Rakshan A. The diagnostic accuracy of fine needle aspiration cytology in neck lymphoid masses. Iran J Pathol 2009; 4: 147–150.
[7] Andriole JG, Haggst JR, Adams RB, Nunez C. Biopsy needle characteristics assessed in the laboratory. Radiology 1983; 148: 659–662.
[8] Yamashita Y, Kurokawa H, Takeda S, Fukuyama H, Takahashi T. Preoperative histologic assessment of head and neck lesions using cutting needle biopsy. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002; 93: 528–533.
[9] Kraft M, Gurtler N, Schmutziger N, Arnoux A. Ultrasound-guided core-needle biopsy in the diagnosis of head and neck lesions. J Laryngol Otol 2007; 121: 895–896.
[10] Ridder GJ, Pfeiffer J. Usefulness of cutting needle biopsy in recurrent and advanced staged head and neck malignancies in a palliative setting. Support Care Cancer 2007; 15: 1301–1307.
[11] Nyquist GG, Tom WD, Mui S. Automatic core needle biopsy—a diagnostic option for head and neck masses. Arch Otolaryngol Head Neck Surg 2008; 134: 184–189.
[12] Bearcroft P, Berman L, Grant J. The use of ultrasound-guided cutting-needle biopsy in the neck. Clin Radiol 2009; 50: 690–695.
[13] Kim BM, Kim EK, Kim MJ, Yang WJ, Park CS, Park SI. Sonographically guided core needle biopsy of cervical lymphadenopathy in patients without known malignancy. J Ultrasound Med 2007; 26: 585–591.
[14] Sreeram NJ, Berman LH, Grant JW. Head and neck lymphadenopathy: evaluation with US-guided cutting-needle biopsy. Radiology 2002; 224: 75–81.
[15] Buckland JR, Manjaly G, Volarius N, Howlett DC. Ultrasound-guided cutting-needle biopsy of the parotid gland. J Laryngol Otol 1989; 113: 988–992.
[16] Frates MC, Benson CB, Charboneau JW, et al. Management of thyroid nodules detected at US: Society of Radiologists in Ultrasound consensus conference statement. Radiology 2005; 237: 794–800.
[17] Alexander EK, Heering JP, Benson CB, et al. Assessment of nondiagnostic ultrasound-guided fine needle aspirations of thyroid nodules. J Clin Endocrinol Metab 2002; 87: 4924–4927.
[18] Strauss EB, Iovine A, Upender S. Simultaneous fine-needle aspiration and core biopsy of thyroid nodules and other superficial head and neck masses during sonographic guidance. AJR 2008; 190: 1697–1699.
[19] Kwak JY, Kim EK, Ko KH, et al. Primary thyroid lymphoma—role of ultrasound-guided needle biopsy. J Ultrasound Med 2007; 26: 1761–1765.
[20] Yuen HY, Lee Y, Bhatia K, Wong KT, Ahuja AT. Use of end-cutting needles in ultrasound-guided biopsy of neck lesions. Eur Radiol 2012; 22: 832–836.
[21] Wong KT, Tsang RKY, Tse GMK, Yuen EHY, Ahuja AT. Biopsy of deep-seated head and neck lesions under intraoral ultrasound guidance. Am J Neuroradiol 2006; 27: 1654–1657.
[22] Shinya S, Tateishi R, Ahuja M, et al. Percutaneous ethanol injection for hepatocellular carcinoma: 20-year outcome and prognostic factors. Liver Int 2012; 32: 1434–1442; doi: 10.1111/j.1478-3231.2012.02838.x.
[23] Tarantino L, Giogio A, Mariniello N, et al. Percutaneous ethanol injection of large autonomous hyperfunctioning thyroid nodules. Radiology 2000; 214: 143–148.
[24] Cho YS, Lee HK, Ahn IM, et al. Sonographically guided ethanol sclerotherapy for benign thyroid cysts: results in 22 patients. AJR 2000; 174: 213–216.
[25] Lewis BD, Hay ID, Charboneau JW, Mclver B, Reading CC, Goellner JR. Percutaneous ethanol injection for treatment of cervical lymph node metastases in patients with papillary thyroid carcinoma. AJR 2002; 178: 699–704.
[26] Ng SK, Yuen HY, Van Hasselt CA, Ahuja AT. Combined ultrasound/endoexcision-assisted vocal fold injection for unilateral vocal cord paralysis: a case series. Eur Radiol 2012; 22: 1110–1113.
[27] Ziegler DM, Amin MR. The thyrohyoid approach to in-office injection augmentation of the vocal fold. Curr Opin Otolaryngol Head Neck Surg 2007; 15: 412–416.
[28] Amin MR. Thyrohyoid approach for vocal fold augmentation. Ann Otol Rhinol Laryngol 2006; 115: 699–702.
[29] Sidhu S, Stanton R, Shahidi S, Chiu J, Chiew S, Campbell P. Initial experience of vocal cord evaluation using grey-scale, realtime, B-mode ultrasound. ANZ J Surg 2011; 71: 737–739.
[30] Friedman EM. Role of ultrasound in the assessment of vocal cord function in infants and children. Ann Otol Rhinol Laryngol 2011; 106: 199–209.
[31] Vats A, Worley GA, De Bruyne R, Porter H, Albert DM, Bailey CM. Laryngeal ultrasound to assess vocal fold paralysis in children. J Laryngol Otol 2004; 108: 429–431.
[32] Onofrio BM. Radiofrequency percutaneous Gasserian ganglion lesions. Results in 140 patients with trigeminal pain. J Neurosurg 1975; 42: 132–139.

[33] Solbiati L, Lerace T, Dellanoce M, et al. Percutaneous US-guided radiofrequency ablation of metastatic lymph nodes from papillary cancer of the thyroid gland: initial experience in two cases [abstract]. Radiology 1998; 209: 385.

[34] Dupuy DE, Mayo-Smith WW, et al. Radiofrequency ablation for the treatment of head and neck neoplasms [abstract]. Radiology 1999; 213: 78.

[35] Dupuy DE, Monchik JM, Decrea C, Pisharodi L. Radiofrequency ablation of regional recurrence from well-differentiated thyroid malignancy. Surgery 2001; 130: 971–977.

[36] Monchik JM, Donatini G, Iannuccilli J, Dupuy DE. Radiofrequency ablation and percutaneous ethanol injection treatment for recurrent local and distant well-differentiated thyroid carcinoma. Ann Surg 2006; 244: 296–304.

[37] Baek JH, Kim YS, Sung JY, Choi H, Lee JH. Loco-regional control of metastatic well-differentiated thyroid cancer by ultrasound-guided radiofrequency ablation. AJR Am J Roentgenol 2011; 197: W331–W336.

[38] Park KW, Shin JH, Han BK, Ko EY, Chung JH. Inoperable symptomatic recurrent thyroid cancers: preliminary result of radiofrequency ablation. Ann Surg Oncol 2011; 18: 2564–2568.

[39] Kim YS, Rhim H, Tae K, Park DW, Kim ST. Radiofrequency ablation of benign cold thyroid nodules: initial clinical experience. Thyroid 2006; 16: 361–367.

[40] Deandrea M, Limone P, Basso E, et al. US-guided percutaneous thermal ablation for the treatment of solid benign hyperfunctioning or compressive thyroid nodules. Ultrasound Med Biol 2008; 34: 784–791.

[41] Baek JH, Jeong HJ, Kim YS, Kwak MS, Lee D. Radiofrequency ablation for an autonomously functioning thyroid node. Thyroid 2008; 18: 675–676.

[42] Jeong WK, Baek JH, Rhim H, et al. Radiofrequency ablation of benign thyroid nodules: safety and imaging follow-up in 236 patients. Eur Radiol 2008; 18: 844–850.

[43] Spiezia S, Garberoglio R, Milone F, et al. Thyroid nodules and related symptoms are stably controlled two years after radiofrequency thermal ablation. Thyroid 2009; 19: 219–225.

[44] Baek JH, Moon WJ, Kim YS, Lee JH, Lee D. Radiofrequency ablation for the treatment of autonomously functioning thyroid nodules. World J Surg 2009; 33: 1971–1977.

[45] Baek JH, Lee JH, Sung JY, et al. Complications encountered in the treatment of benign thyroid nodules with US-guided radiofrequency ablation: a multicenter study. Radiology 2012; 262: 335–342.

[46] Huh JY, Baek JH, Choi H, Kim JK, Lee JH. Symptomatic benign thyroid nodules: efficacy of additional radiofrequency ablation treatment session—prospective randomized study. Radiology 2012; 263: 909–916.

[47] Ha EJ, Baek JH, Lee JH, et al. Radiofrequency ablation of benign thyroid nodules does not affect thyroid function in patients with previous lobectomy. Thyroid 2013; 23: 289–293.

[48] Lim HK, Lee JH, Ha EJ, Sung JY, Kim JK, Baek JH. Radiofrequency ablation of benign non-functioning thyroid nodules: 4-year follow-up results for 111 patients. Eur Radiol 2013; 23: 1044–1049.

[49] Baek JH, Kim YS, Lee D, Huh JY, Lee JH. Benign predominantly solid thyroid nodules: prospective study of efficacy of sonographically guided radiofrequency ablation versus control condition. AJR Am J Roentgenol 2010; 194: 1137–1142.

[50] Bui QT, Dupuy DE. Percutaneous CT-Guided radiofrequency ablation of an adenoid cystic carcinoma of the head and neck. AJR Am J Roentgenol 2002; 179: 1333–1335.

[51] Brook AL, Gold MM, Miller TS, et al. CT-guided radiofrequency ablation in the palliative treatment of recurrent advanced head and neck malignancies. J Vasc Interv Radiol 2008; 19: 725–735.

[52] Owen RP, Khan SA, Negassa A, et al. Radiofrequency ablation of advanced head and neck cancer. Arch Otolaryngol Head Neck Surg 2011; 137: 493–498.

[53] Rhim H, Goldberg SN, Dodd GD 3rd, et al. Essential techniques for successful radiofrequency thermal ablation of malignant hepatic tumours. Radiographics 2001; 21: S17–35; discussion S36–39.

[54] Baek JH, Lee JH, Valcavi R, Pacella CM, Rhim H, Na DG. Thermal ablation for benign thyroid nodules: radiofrequency and laser. Korean J Radiol 2011; 12: 525–540.

[55] Sung JY, Kim YS, Choi H, Lee JH, Baek JH. Optimum first-line treatment technique for benign cystic thyroid nodules: ethanol ablation or radiofrequency ablation? AJR Am J Roentgenol 2011; 196: W210–214.

[56] Na DG, Lee JH, Jung SL, et al. Radiofrequency ablation of benign thyroid nodules and recurrent thyroid cancers: consensus statement and recommendations. Korean J Radiol 2012; 13: 117–125; doi: 10.3348/kjr.2012.13.2.117.