ELSEVIER

Radiotherapy and Oncology 69 (2003) 227–236

RADIOTHERAPY & ONCOLOGY
JOURNAL OF THE EUROPEAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY

www.elsevier.com/locate/radonline

CT-based delineation of lymph node levels and related CTVs in the node-negative neck: DAHANCA, EORTC, GORTEC, NCIC, RTOG consensus guidelines

Vincent Grégoire[a,*,1], Peter Levendag[b,1], Kian K. Ang[c], Jacques Bernier[d], Marijel Braaksma[b], Volker Budach[e], Cliff Chao[c], Emmanuel Coche[f], Jay S. Cooper[c], Guy Cosnard[f], Avraham Eisbruch[c], Samy El-Sayed[g], Bahman Emami[c], Cai Grau[h], Marc Hamoir[i], Nancy Lee[c], Philippe Maingon[j], Karin Muller[b], Hervé Reychler[k]

[a]*Radiation Oncology Dept. and Laboratory of Radiobiology, Université Catholique de Louvain, St-Luc University Hospital, B-1200 Brussels, Belgium*
[b]*Radiation Oncology Dept., Erasmus Medical Center Daniel den Hoed Cancer Center, Rotterdam, The Netherlands*
[c]*Head and Neck group, RTOG, 1101 Market Street, 14th Floor, Philadelphia, PA 19107, USA*
[d]*Head and Neck group, EORTC, Avenue E. Mounier, 83/11, B-1200 Brussels, Belgium*
[e]*Radiotherapy group, EORTC, Avenue E. Mounier, 83/11, B-1200 Brussels, Belgium*
[f]*Radiology Dept., Université Catholique de Louvain, St-Luc University Hospital, B-1200 Brussels, Belgium*
[g]*Head and Neck DSG, NCIC-CTG, 10 Alcorn Avenue, Suite 200, Toronto, Ont., Canada, M4V 3B1*
[h]*DAHANCA, Norrebrogade 44, 8000 Aarhus C, Denmark*
[i]*Head and Neck Surgery Dept., Université Catholique de Louvain, St-Luc University Hospital, B-1200 Brussels, Belgium*
[j]*GORTEC, Rue C. Desmoulins, 39, 94805, Villejuif, France*
[h]*Maxillo-Facial Surgery Dept., Université Catholique de Louvain, St-Luc University Hospital, B-1200 Brussels, Belgium*

Received 4 July 2003; received in revised form 18 August 2003; accepted 12 September 2003

Abstract

Background and purpose: The appropriate application of 3-D CRT and IMRT for HNSCC requires a standardization of the procedures for the delineation of the target volumes. Over the past few years, two proposals—the so-called Brussels guidelines from Grégoire et al., and the so-called Rotterdam guidelines from Nowak et al.—emerged from the literature for the delineation of the neck node levels. Detailed examination of these proposals however revealed some important discrepancies.

Materials and methods: Within this framework, the Brussels and Rotterdam groups decided to review their guidelines and derive a common set of recommendations for delineation of neck node levels. This proposal was then discussed with representatives of major cooperative groups in Europe (DAHANCA, EORTC, GORTEC) and in North America (NCIC, RTOG), which, after some additional refinements, have endorsed them. The objective of the present article is to present the consensus guidelines for the delineation of the node levels in the node-negative neck.

Results and conclusions: First a short discussion of the discrepancies between the previous Brussels and the Rotterdam guidelines is presented. The general philosophy of the consensus guidelines and the methodology used to resolve the various discrepancies are then described. The consensus proposal is then presented and representative CTVs that are consistent with these guidelines are illustrated on CT sections. Last, the limitations of the consensus guidelines are discussed and some concerns about the direct applications of these guidelines to the node-positive neck and the post-operative neck are described.

Keywords: Radiotherapy; Head and neck; Node levels; Guidelines

1. Introduction

The implementation of three-dimensional conformal radiotherapy (3D-CRT) and intensity-modulated radiation therapy (IMRT) permits far greater control of dose

* Corresponding author.
[1] Both authors contributed equally to the paper.

0167-8140/$ - see front matter © 2003 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.radonc.2003.09.011

distribution, selection and the delineation of target volumes. This new capability is particularly important for the management of tumors in the head and neck region, where, with few exceptions (e.g. early stage laryngeal and oral cavity tumors), radiation oncologists previously have been used to comprehensive treatment of all neck node levels. In recent years, however, it has been suggested that more selective treatment of the neck nodes could lead to substantial reduction in the dose inflicted on critical organs at risk, such as the parotids, without jeopardizing loco-regional control [3,8]. However, sub-optimal selection and delineation of target volumes could easily jeopardize the clinical impact of the exquisite dose distributions produced.

Over the past few years, several authors have advocated the concept of limited treatment, i.e. selective neck dissection or selective neck irradiation, for limited stage tumors (see reviews in Refs. [2,6,7,9]). It is beyond the scope of this article to discuss this issue at length. But, comprehensive review of the literature has indicated that in the previously untreated neck, the lymph node drainage of the oral cavity, larynx and pharynx follows a sufficiently predictable pattern that the concept of selective treatment has a legitimate rationale. The application of this concept however requires standardization of the terminology and procedures for both neck dissection and neck irradiation. In 1991, the Committee for Head and Neck Surgery and Oncology of the American Academy for Otolaryngology—Head and Neck Surgery proposed a set of definitions of the various lymph node dissection procedures [15]. These recommendations, popularized by Robbins, were based on a systematic classification of the neck nodes into six levels, the boundaries of each being defined by surgically visible bones, muscles, blood vessels or nerves. These recommendations recently have been updated, with refinements of some boundaries using radiologic landmarks, and further definition of sub-levels (e.g. IIa–IIb, Va–Vb) [16,17]. In the wake of these recommendations, several groups have translated the anatomic boundaries of the various neck node levels on CT- or MR-scans [2,9,13,14,19,20]. In the Radiation Oncology community, two of these guideline proposals—the so-called Brussels guidelines from Grégoire et al., and the so-called Rotterdam guidelines from Nowak et al.—appear to be the most widely used in clinical practice [9,14]. The Rotterdam guidelines have further evolved into a simplified version that their authors consider more usable in a routine practice [20]. Detailed examination of the Brussels and Rotterdam recommendations, however, reveals some important discrepancies, preventing uniform delineation of the target volumes in the neck among radiation oncologists.

Within this framework, the Brussels and Rotterdam groups decided to review their guidelines and derive a common set of recommendations for delineation of neck node levels [11]. This proposal was then discussed with representatives of major cooperative groups in Europe (DAHANCA, EORTC, GORTEC) and in North America (NCIC, RTOG), which, after some additional refinements, have endorsed them. The objective of the present article is to present the consensus guidelines for the delineation of the node levels in the node-negative neck. First a short discussion of the discrepancies between the previous Brussels and the Rotterdam guidelines is presented. The general philosophy of the consensus guidelines and the methodology used to resolve the various discrepancies are then described. The consensus proposal is then presented and representative clinical tumor volumes (CTVs) that are consistent with these guidelines are illustrated on CT sections. Last, the limitations of the consensus guidelines are discussed and some concerns about the direct applications of these guidelines to the node-positive neck and the post-operative neck are described.

2. The Brussels and the Rotterdam guidelines for lymph node level delineation in the node-negative neck

The Brussels proposal was an attempt to translate precisely the concept of neck node levels as defined by Robbins on CT slices using similar anatomic boundaries, and to extend the concept to nodes not covered by Robbins, i.e. the retropharyngeal nodes. A few anatomic boundaries originally defined by nerves, vessels or muscles had to be adapted to take into account the limitations and advantages of CT scans. Robbins originally described the cranial limit of level II as the base of skull. In reality, surgeons used the insertion of the posterior belly of the digastric muscle to the mastoid as the cranial limit of level II; the Brussels guidelines instead used the bottom edge of the body of C1, which is easily identifiable on CT scan. Similarly, Robbins defined the caudal limit of level III as the point at which the omohyoid muscle crossed the internal jugular vein (IJV); the Brussels guidelines instead defined the caudal limit of level III as the bottom edge of the cricoid cartilage. Lastly, Robbins used the spinal accessory nerve (SAN) to sub-divide level II into IIa (anterior to a vertical plane defined by the nerve) and IIb (posterior to that plane). Because the SAN cannot be identified on CT scans, the Brussels guidelines, as proposed by Som, used the posterior edge of the IJV for the subdivision between levels IIa and IIb [19].

The Rotterdam proposals comprised two sets of guidelines, the original one published by Nowak in 1999, and a ‘simplified’ version published by Wijers et al. later in the same year [14,20]. The retropharyngeal lymph nodes were identified in neither of these two proposals. For the original guidelines, a radical modified neck dissection was performed on a cadaver and the various boundaries of the node levels were demarcated. These boundaries where then translated onto a second frozen cadaver which had been CT-scanned and cut into 5 mm thick sections.

The boundaries of the surgical levels could then be precisely projected onto the matched CT slices.

Although developed with similar objectives, the Brussels and the original Rotterdam guidelines differed substantially. For example, differences existed in the definitions of the cranial border of level II, the posterior border of levels II, III, IV and V, the cranial border of level V and the caudal border of level VI. Readers are referred to the original publications for a comprehensive description of the original recommendations [9,14].

The second simplified version of the Rotterdam guidelines was developed not only to substitute boundaries which were easier to identify (e.g. vertebral bodies, salivary glands, pharyngo-laryngeal lumen) than the original anatomical boundaries, but also to allow delineation of different nodal levels on a limited number of CT slices, from which the all neck levels could be reconstructed by interpolation. This simplified protocol substantially reduced the contouring time and allowed selective neck irradiation with similar parotid gland sparing compared to the original Rotterdam guidelines. However, differences between the simplified version of the Rotterdam guidelines and the Brussels guidelines were even greater than between the original Rotterdam and Brussels guidelines (Fig. 1).

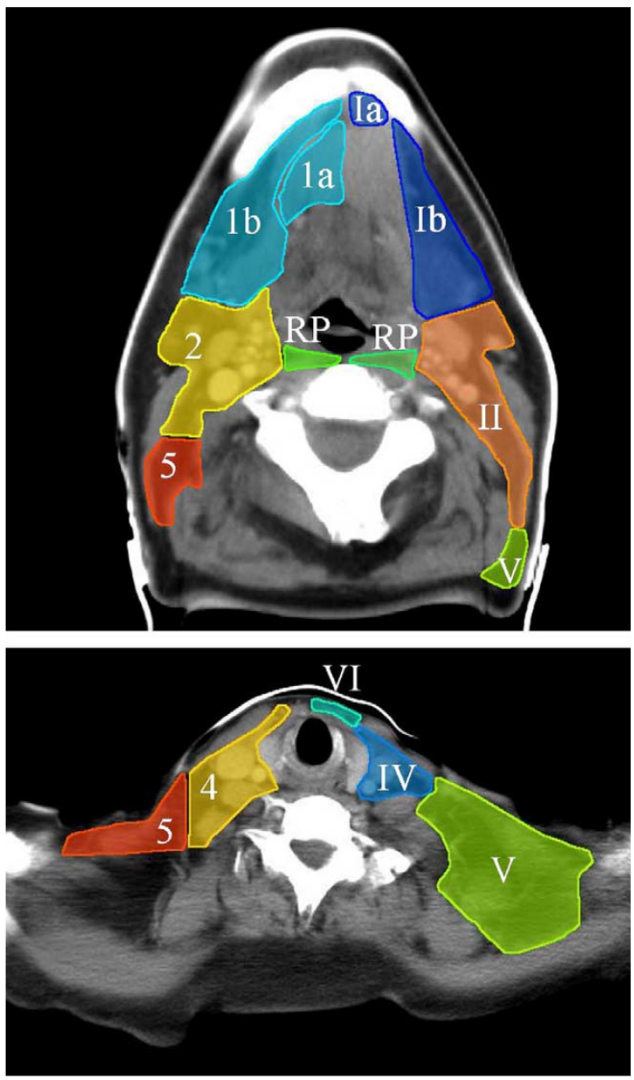

Fig. 1. Comparison between the simplified Rotterdam (left side of the neck, Arabic figures) and the Brussels (right side of the neck, roman figures) guidelines for the delineation of the neck node levels. On the top, CT slice at the level of the basilar edge of the mandible; levels Ia, Ib, II and V, and retropharyngeal nodes (RP) are displayed. On the bottom, CT slice at the level of the cricoid cartilage; levels IV, V and VI are displayed.

3. General methodology used to reach the consensus guidelines for the delineation of the neck node levels

In view of the differences observed between the Brussels and the Rotterdam guidelines, a multidisciplinary working group, including members from both the original Brussels and Rotterdam groups, was created to try to create a unified set of recommendations for the delineation of the various levels in the clinically uninvolved, 'node-negative' neck. Subsequently, the working group was enlarged to include representatives of American and European cooperative groups. All of the physicians who contributed to the creation of these guidelines are listed as co-authors of this manuscript. The general principles which guided the activities of the working group were (1) to translate as accurately as possible the surgical guidelines into radiologic guidelines based on axial CT sections, and (2) to minimize differences in interpretation of the guidelines, by defining less ambiguous boundaries than previously described.

Several factors motivated the panel to use the previously described surgical guidelines as their basic frame of reference. First, perhaps more than anywhere else, achievements in head and neck oncology have resulted from complementary interactions of surgery and radiotherapy. This complementarity will become even more critical for future advances based on 3D-CRT and/or IMRT since increasingly more precise doses will be delivered to increasingly more precise target volumes. This prompts us to advocate for the use of a similar language to that already used by surgeons for more than a decade. Second, in properly selected patients, neck node dissection performed according to standardized procedures, removing only selected nodal levels, has produced high rates of control in the pathologically assessed node-negative neck, without post-operative radiotherapy [1]. This observation confirmed that the locations of the lymphatic areas at risk for microscopic infiltration often are well-defined, and retrospectively validated the use of selective tissue dissection as an effective prophylactic treatment modality for the neck of selected patients. Third, to some extent in the past, the selection and the delineation of the target volumes for head and neck radiotherapy were driven more by technical limitations than by patient anatomy. This lead to unavoidable, unnecessary irradiation of normal tissues bearing little or no risk of tumor cell infiltration, with the potential risk of acute and/or late complications of treatment. In this framework, the use of

a so-called 'surgical reference system' was felt to be more appropriate than an accurate translation of 2D irradiation techniques into 3D volumes.

Practically, with the help of head and neck surgeons and diagnostic radiologists, all the landmarks used to delineate the various node levels during a neck dissection were located on axial CT slices. The surgical boundaries were critically reviewed and, for some of them (e.g. upper limit of level V), new data recently published were taken into account [10]. To have better correspondence of some of these landmarks (e.g. the upper limit of levels II and V, the lower limit of level IV) with anatomic structures easily identifiable on CT scans, radio-opaque vascular clips were placed during neck node dissections and visualized on CT studies performed in the post-operative period. When landmarks used by surgeons were felt somehow ambiguous and/or subject to inter-observer variation (e.g. the caudal limit of level IV, the posterior limit of level V in the lower neck), new, consensus landmarks were proposed by the panel.

4. The consensus guidelines for the delineation of the node levels in the node-negative neck

The consensus guidelines for the delineation of levels I–VI and the retropharyngeal lymph nodes are presented in Table 1. The boundaries refer to a patient lying supine with his/her head in a 'neutral' position. The terms 'cranial' and 'caudal' refer to structures closer to the cephalic and pedal ends, respectively. The terms 'anterior' and 'posterior' were chosen to be less confusing than the terms 'ventral' and 'dorsal', respectively.

4.1. Levels Ia and Ib

Level Ia (Fig. 2B) is a unique median region which contains the submental nodes. The lymph nodes are located in a triangular region limited anteriorly by the platysma muscle and the symphysis menti, posteriorly by the body of the hyoid bone, cranially by the geniohyoid muscle or a plane tangent to the basilar edge of the mandible, caudally by the hyoid bone, and laterally by the medial edge of the anterior belly of the digastric muscle. The medial limit of level Ia is virtual, as the region continues into the contralateral level Ia.

Nodes in level Ia drain the skin of the chin, the mid-lower lip, the tip of the tongue, and the anterior floor of the mouth [18]. Level Ia is at greatest risk of harboring metastases from cancer arising from the floor of the mouth, the anterior oral tongue, the anterior mandibular alveolar ridge, and the lower lip.

Level Ib (Fig. 2B and C) contains the submandibular nodes. It is located within the boundaries of the anterior and posterior belly of the digastric muscle, the stylohyoid muscle and the body of the mandible. It is limited anteriorly by the platysma muscle and the symphysis menti, posteriorly by the posterior edge of the submandibular gland, medially by the lateral edge of the anterior belly of the digastric muscle, and laterally by the basilar edge and inner side of the mandible, the platysma and the skin. Cranially it is limited by the mylohyoid muscle and the cranial edge of the submandibular gland, and caudally by a plane crossing the central part of the hyoid bone.

The submandibular nodes receive efferent lymphatics from the submental lymph nodes, the medial canthus, the lower nasal cavity, the hard and soft palate, the maxillary and mandibular alveolar ridges, the cheek, the upper and lower lips, and most of the anterior tongue [18]. Nodes in level Ib are at risk of developing metastases from cancers of the oral cavity, anterior nasal cavity, soft tissue structures of the mid-face and the submandibular gland.

4.2. Levels IIa and IIb

Level II (Fig. 2A–C) contains the upper jugular lymph nodes located around the upper one-third of the IJV and the upper SAN. It extends from the base of the skull to the carotid bifurcation (surgical landmark) or the caudal border of the body of the hyoid bone (clinical landmark). Level II is limited anteriorly by the posterior edge of the submandibular gland, the anterior edge of the carotid artery and the posterior belly of the digastric muscle, posteriorly by the posterior edge of the sternocleidomastoid (SCM) muscle, medially by the medial edge of the carotid artery and the paraspinal muscles (levator scapulae and splenius capitis), and laterally by the medial edge of the SCM and the platysma. Cranially, the panel proposed to set the cranial limit of level II at the caudal edge of the lateral process of the first vertebra, which is an easiest landmark than the insertion of the posterior belly of the digastric muscle to the mastoid which is the surgical landmark (Figs. 3 and 4). For retropharyngeal primary tumors, the cranial limit of level II should be extended to include the jugular fossa. Caudally, level II is limited by the body of the hyoid bone.

Level II is further subdivided into two compartments. The lymph nodes located anteriorly to a vertical plane defined by the upper one-third of the SAN (surgical landmark) are included in level IIa, whereas the lymph nodes located posteriorly to the SAN are included in level IIb. From a radiological point of view, the posterior edge of the IJV is taken as the boundary between levels IIa and IIb.

Level II receives efferent lymphatics from the face, the parotid gland, and the submandibular, submental and retropharyngeal nodes. Level II also directly receives the collecting lymphatics from the nasal cavity, the pharynx, the larynx, the external auditory canal, the middle ear, and the sublingual and submandibular glands [18]. The nodes in level II are therefore at greatest risk of harboring metastases from cancers of the nasal cavity, oral cavity, nasopharynx, oropharynx, hypopharynx, larynx, and the major salivary glands. Level IIb is more likely associated with primary tumors of the oropharynx or nasopharynx, and less frequently with tumors of the oral cavity, larynx or hypopharynx.

Table 1
Consensus guidelines for the radiological boundaries of the neck node levels

Level	Anatomical boundaries					
	Cranial	Caudal	Anterior	Posterior	Lateral	Medial
Ia	Geniohyoid m., plane tangent to basilar edge of mandible	Plane tangent to body of hyoid bone	Symphysis menti, platysma m.	Body of hyoid bone	Medial edge of ant. belly of digastric m.	n.a.[a]
Ib	Mylohyoid m., cranial edge of submandibular gland	Plane through central part of hyoid bone	Symphysis menti, platysma m.	Posterior edge of submandibular gland	Basilar edge/innerside of mandible, platysma m., skin	Lateral edge of ant. belly of digastric m.
IIa	Caudal edge of lateral process of C1	Caudal edge of the body of hyoid bone	Post. edge of sub-mandibular gland; ant. edge of int. carotid artery; post. edge of post. belly of digastric m.	Post. border of int. jugular vein	Medial edge of sternocleidomastoid	Medial edge of int. carotid artery, paraspinal (levator scapulae) m.
IIb	Caudal edge of lateral process of C1	Caudal edge of the body of hyoid bone	Post. border of int. jugular vein	Post. border of the sternocleidomastoid m.	Medial edge of sternocleidomastoid	Medial edge of int. carotid artery, paraspinal (levator scapulae) m.
III	Caudal edge of the body of hyoid bone	Caudal edge of cricoid cartilage	Postero-lateral edge of the sternohyoid m.; ant. edge of sternocleidomastoid m.	Post. edge of the sternocleidomastoid m.	Medial edge of sternocleidomastoid	Int. edge of carotid artery, paraspinal (scalenius) m.
IV	Caudal edge of cricoid cartilage	2 cm cranial to sternoclavicular joint	Anteromedial edge of sternocleido-mastoid m	Post. edge of the sternocleidomastoid m.	Medial edge of sternocleidomastoid	Medial edge of internal carotid artery, paraspinal (scalenius) m.
V	Cranial edge of body of hyoid bone	CT slice encompassing the transverse cervical vessels[b]	Post. edge of the sternocleidomastoid m.	Ant-lateral border of the trapezius m.	Platysma m., skin	Paraspinal (levator scapulae, splenius capitis) m.
VI	Caudal edge of body of thyroid cartilage[c]	Sternal manubrium	Skin; platysma m.	Separation between trachea and esophagus[d]	Medial edges of thyroid gland, skin and ant.-medial edge of sternocleidomastoid m.	n.a.
Retro-pharyngeal	Base of skull	Cranial edge of the body of hyoid bone	Fascia under the pharyngeal mucosa	Prevertebral m. (longus colli, longus capitis)	Medial edge of the internal carotid artery	Midline

[a] Midline structure lying between the medial borders of the anterior bellies of the digastric muscles.
[b] For NPC, the reader is referred to the original description of the UICC/AJCC 1997 edition of the Ho's triangle. In essence, the fatty planes below and around the clavicle down to the trapezius muscle.
[c] For paratracheal and recurrent nodes, the cranial border is the caudal edge of the cricoid cartilage.
[d] For pretracheal nodes, trachea and anterior edge of cricoid cartilage.

4.3. Level III

Level III (Fig. 2D) contains the middle jugular lymph nodes located around the middle third of the IJV. It is the caudal extension of level II. It is limited cranially by the caudal edge of the body of the hyoid bone, and caudally by the caudal edge of the cricoid cartilage. The anterior limit is the posterolateral edge of the sternohyoid muscle and the anterior edge of the SCM muscle, and the posterior limit is the posterior edge of the SCM muscle. Laterally, level III is

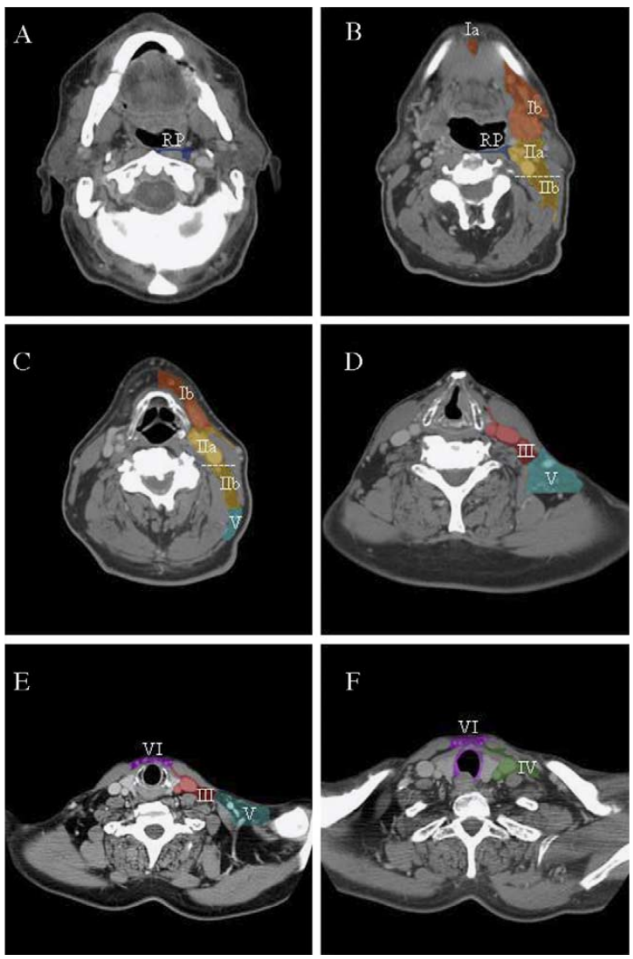

Fig. 2. CT imaging of a patient with a T1N0M0 glottic SCC (see tumor in panel D). The examination was performed on a dual-detector spiral CT (Elscint Twin, Haifa, Israel) using a slice thickness of 2.7 mm, an interval reconstruction of 2 mm and a pitch of 0.7.Contrast medium was injected intravenously at a rate of 2 ml/s with a total amount of 100 ml. Sections were taken at the level of the bottom edge of C1 (panel A), the upper edge of C3 (panel B), mid C4 (panel C), the bottom edge of C6 (panel D), the bottom edge of C7 (panel E), and mid D1 (panel F). Neck node levels were drawn on each CT slice using the radiological boundaries detailed in Table 1. Each node level corresponds to the CTV, and thus does not include any security margin for organ motion or set-up inaccuracy.

limited by the medial edge of the SCM muscle and medially by the medial edge of the internal carotid artery and the paraspinal muscles (scalenius).

Level III contains a highly variable number of lymph nodes and receives efferent lymphatics from levels II and V, and some efferent lymphatics from the retropharyngeal, pretracheal and recurrent laryngeal nodes. It collects the lymphatics from the base of the tongue, tonsils, larynx, hypopharynx and thyroid gland [18]. Nodes in level III are at greatest risk of harboring metastases from cancers of the oral cavity, nasopharynx, oropharynx, hypopharynx and larynx.

4.4. Level IV

Level IV (Fig. 2F) includes the lower jugular lymph nodes located around the inferior third of the IJV. According to Robbins, it extends from the caudal limit of level III to the clavicle [15]. However, it appears from critical examination of surgical procedures that dissection of level IV typically does not go all the way down to the clavicle and definitely never reaches the medial portion of the clavicle at the level of the sternoclavicular joint (Fig. 3). Consequently, it was agreed among the panel to set the caudal limit of level IV 2 cm cranially to the cranial edge of the sternoclavicular joint. The cranial limit of level IV is the caudal edge of the cricoid cartilage. The anterior and posterior limits are the same as of level III, i.e. the anteromedial edge and the posterior edge of the SCM muscle, respectively. Laterally, level IV is limited by the medial edge of the SCM muscle and medially by the medial edge of the internal carotid artery and the paraspinal muscles (scalenius).

Level IV contains a variable number of nodes and receives efferent lymphatics primarily from levels III and V, some efferent lymphatics from the retropharyngeal, pretracheal and recurrent laryngeal nodes, and collecting lymphatics from the hypopharynx, larynx and thyroid gland [18]. Level IV nodes are at high risk of harboring

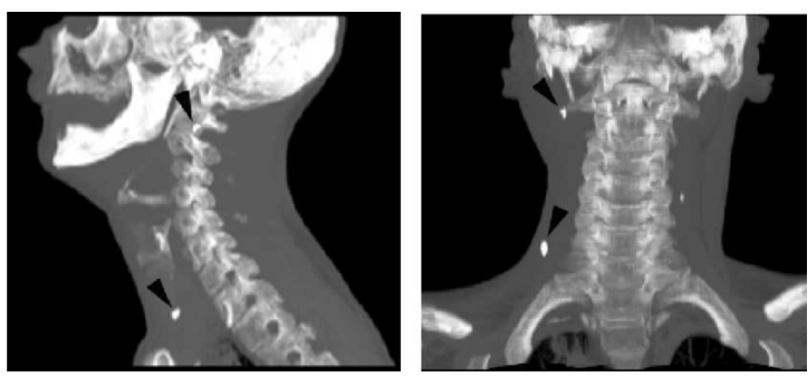

Fig. 3. Thick coronal (top) and sagittal (bottom) reconstruction with volume rendering. The examination was performed on a dual-detector spiral CT (Elscint Twin, Haifa, Israel) using a slice thickness of 2.7 mm, an interval reconstruction of 2 mm and a pitch of 0.7. Radio-opaque clips were placed during the neck dissection procedure at the cranial limit of levels II (top arrow head) and at the caudal limit of level IV (bottom arrow head). The examination was performed within 3–4 weeks after surgery.

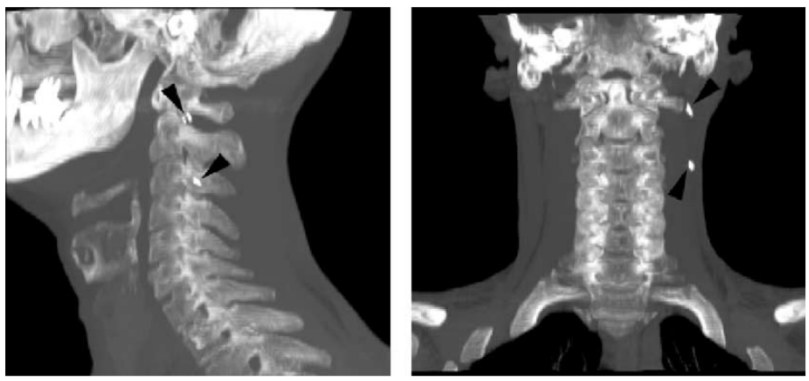

Fig. 4. Thick coronal (top) and sagittal (bottom) reconstruction with volume rendering. The examination was performed on a dual-detector spiral CT (Elscint Twin, Haifa, Israel) using a slice thickness of 2.7 mm, an interval reconstruction of 2 mm and a pitch of 0.7. Radio-opaque clips were placed during the neck dissection procedure at the cranial limit of levels II (top arrow head) and V (bottom arrow head). The examination was performed within 3–4 weeks after surgery.

metastases from cancers of the hypopharynx, larynx and cervical esophagus.

4.5. Level V

Level V (Fig. 2C–E) includes the lymph nodes of the posterior triangle group. This group includes the lymph nodes located along the lower part of the SAN and the transverse cervical vessels. According to Robbins, level V is limited cranially by the convergence of the SCM and the trapezius muscles, and caudally by the clavicle [15]. However, the uppermost part of level V is devoid of any constant lymph node group. In some circumstances, a few lymph nodes lying along the upper third of the SAN may be found, but these nodes are actually included in level IIb [16]. The uppermost part of level V contains superficial occipital lymph node(s), and inconsistently, one subfascial lymph node close to the occipital attachment of the SCM muscle [18]. These lymph nodes collect lymphatics from the occipital scalp, and the post-auricular and nuchal regions. They are not involved in the drainage of head and neck cancers except of skin tumors. Consequently, the cranial limit of level V that is commonly accepted and depicted has been questioned. Hamoir et al. has recently proposed to use the lower two-thirds of the SAN as the cranial limit of level V [10]. From a radiological point of view, a horizontal plane crossing the cranial edge of the body of the hyoid bone appears as a reliable landmark for the cranial limit of level V (Fig. 4). For the caudal limit of level V, it appears from critical examination of neck dissection procedure, that surgeons never dissect the neck further down to the cervical transverse vessels. It was thus agreed by the panel to set the caudal limit of level V at CT slices encompassing the cervical transverse vessels. For the other boundaries, level V is limited laterally by the platysma muscle and the skin, and medially by the splenius capitis, levator scapulae and scaleni (posterior, medial and anterior) muscles. Anteriorly, it is limited by the posterior edge of the SCM muscle, and posteriorly by the antero-lateral border of the trapezius muscle. This later boundary means that level V does not extend posteriorly all the way to the anterior edge of the trapezius muscle. Practically, a virtual line joining the antero-lateral border of both trapezius muscles can be use to set the posterior limit of level V (Fig. 2D and E).

Level V receives efferent lymphatics from the occipital and post-auricular nodes as well as those from the occipital and parietal scalp, the skin of the lateral and posterior neck and shoulder, the nasopharynx and the oropharynx (tonsils and base of the tongue) [18]. Level V lymph nodes are at high risk or harboring metastases from cancers of the nasopharynx, oropharynx, subglottic larynx, the apex of the piriform sinus, the cervical esophagus and the thyroid gland.

4.6. Level VI

Level VI (Fig. 2D–F), also called the anterior neck compartment, contains the lymph nodes located in the visceral space: the pre- and paratracheal nodes including the precricoid (Delphian) node and the perithyroid nodes including the lymph nodes along the recurrent laryngeal nerves. It is limited cranially by the caudal edge of the body of the thyroid cartilage, caudally by the cranial edge of the sternal manubrium, anteriorly by the platysma and the skin and posteriorly by the separation between the trachea and the esophagus. The lateral limit is the medial edge of the thyroid gland, the skin and the antero-medial edge of the SCM muscle. For the paratracheal and recurrent nodes, the cranial limit is the caudal edge of the cricoid cartilage. For the pretracheal nodes, the posterior limit is the trachea and the anterior edge of the cricoid cartilage (Fig. 2E).

Level VI receives efferent lymphatics from the thyroid gland, the glottic and subglottic larynx, the hypopharynx and the cervical esophagus [18]. These nodes are at high risk or harboring metastases from cancers of the thyroid gland, the glottic and subglottic larynx, the apex of the piriform sinus and the cervical esophagus.

4.7. Retropharyngeal nodes

Retropharyngeal lymph nodes (Fig. 2A and B) lie within the retropharyngeal space, which extends cranially from the base of the skull to the cranial edge of the body of the hyoid bone caudally. This space is bounded anteriorly by the pharyngeal constrictor muscles, and posteriorly by the prevertebral fascia. For the sake of simplicity and consistency, the panel proposed to use the fascia below the pharyngeal mucosa as the anterior limit, and the prevertebral muscle (longus colli and longus capitis) as the posterior limit. Laterally, the retropharyngeal nodes are limited by the medial edge of the internal carotid artery. Typically, retropharyngeal nodes are divided into a medial and a lateral group. The medial group is an inconsistent group which consist of one to two lymph nodes intercalated in or near the midline. The lateral group lies medial to the carotid artery. The most superior lymph node of this group is also called the lymph node of Rouvière.

Retropharyngeal node involvement occurs in primary tumors arising from (or invading) the mucosa of the occipital and cervical somites, e.g. of the nasopharynx, the pharyngeal wall and the soft palate. Retropharyngeal nodes are also at risk in case of pharyngeal tumors with positive neck nodes in other levels in the neck [4,5,12].

5. Implications of nodal levels for the creation of clinical tumor volumes

Just as modern head and neck surgeons selectively can dissect one or more nodal levels successfully, it seems logical to believe that modern radiation oncologists should be able to irradiate similarly selected nodal levels. At present, the ability to examine surgical specimens histologically has no radiotherapeutic counterpart, and the criteria and confidence for selective irradiation of limited nodal levels is therefore more limited. While the criteria for such selective therapy likely will need to be refined over the coming years (and are not the subject of this report), the CTVs that will need to be irradiated to encompass the various nodal levels can be defined now. Examples of CTVs that adequately encompass the delineated node levels are shown in Fig. 2. A complete atlas of contrast-enhanced CT sections depicting guideline CTVs that encompass the various node levels from the base of skull to the level of the sterno-clavicular joints have been posted on the DAHANCA (http://www.dshho.suite.dk/dahanca/guidelines.html), EORTC (http://groups.eortc.be/radio/EDUCATION.htm) and RTOG (http://www.rtog.org/hnatlas/main.htm) websites.

6. Discussion

The consensus guidelines presented previously reflect in-depth discussions of a panel of European and American experts from various head and neck disciplines, i.e. radiation oncologists, radiologists and surgeons. Their objective was to create a set of common recommendations for radiation oncologists to use in their daily practice for the delineation of the various neck node levels on CT sections. These guidelines were then presented to the relevant major European and North American cooperative groups in radiation oncology (DAHANCA, EORTC, GORTEC, NCIC, RTOG), which subsequently endorsed them.

When reading these guidelines, the following limitations must be clearly understood

- These guidelines do not intend to give any recommendation for the optimal treatment strategy (observation versus prophylactic irradiation) for node-negative patients with a head and neck primary, or the selection of various levels that require treatment. Recent review publications have begun to address these issues from the surgical and the radiotherapeutic perspective [2,6,7,9]. In the future, additional bases for such decisions will be forthcoming. In the meanwhile, physicians will have to weigh the available data on patterns of lymph node infiltration for various locations, grade and extent of the primary, the probability of treatment morbidity (e.g. higher risk of xerostomia in case of retropharyngeal node irradiation), and the ability to perform an effective salvage treatment in case of neck recurrence. We currently take no stand, instead leaving this decision to interdisciplinary head and neck tumor boards and institutional policies in every center.
- The levels delineated in Fig. 2 correspond to the Clinical Target Volumes (CTV), and thus do not include any security margin for organ motion and/or set-up uncertainty. The magnitude of such security margin required to generate the Planning Target Volume (PTV) will be based on the infrastructure and experience of each center.
- These guidelines are defined solely for the irradiation of node-negative, surgically naïve necks, i.e. necks with no detectable tumor despite adequate imaging assessment, and necks with no alteration of their anatomy due to previous surgery. At present, it is unclear if these guidelines can be extrapolated to the node-positive neck and/or the post-operative situation. The panel agreed that the general principles that form the basis of the consensus guidelines still hold, but that additional recommendations should take into account the probability of tumor spread into adjacent anatomic structures at risk.
- In the node-positive neck, an important factor to consider is the possibility of capsular rupture and extracapsular extension (ECE). The risk of ECE is directly proportional to the size of the lymph node, typically being 20–40% for nodes smaller than 1 cm in diameter, and above 75% for bulky nodes more than 3 cm in diameter (see review in Ref. [2]). Thus, for patients with very small, but detectable, nodes, it is reasonable to consider that the consensus guideline presented in this manuscript may

still hold. For patients who have nodes more than 3 cm in diameter, it appears that additional adjacent structures at risk of tumor infiltration (e.g. the SCM and/or paraspinal muscles) should also be included in the CTV. It is known that muscular fascias are strong barriers against muscle infiltration, and that when the fascia has been disrupted, the whole muscle is at risk as tumor cells easily propagate in the fatty tissue along the muscular fibers. Whether the entire muscle should be included in the CTV, or only a portion of it in the immediate vicinity of the node, is unknown. But because head and neck IMRT is still in its infancy, it does not seem inappropriate to cover the muscle more generously, at least up to a prophylactic dose. Another important question for the node-positive neck, is whether the cranial limit (towards the base of skull) and caudal limit (toward the supraclavicular area) of the CTV should be enlarged. Again, there is no definite answer to this question, but it seems reasonable in case of infiltration of the upper part of level II to include the jugular fossae in the CTV, and/or to include the supraclavicular area in case of lower neck infiltration. Such recommendations are in good agreement with the pattern of relapse observed after IMRT treatment where selective CTVs have been delineated [3,8].

- In the post-operative situation, it seems logical to try to cover at least the entire operative bed, especially in case of ECE. In addition, additional structures may need to be included in the CTV based on the pathologic findings. For example, in case of ECE with infiltration of the fascia of the paraspinal muscles, these muscles probably should be considered at high risk and included in the CTV. Similarly, the CTV may need to be enlarged to include the jugular fossae in case of nodal involvement of the cranial aspect of level II. Again, because head and neck IMRT is still in its infancy, it does not seem inappropriate to be generous in target volume delineation until more data are available on the pattern of recurrence after selective treatment.

7. Conclusions

Complex 3D-CRT and IMRT for the treatment of head and neck cancers requires appropriate selection and accurate delineation of target volumes for successful treatment delivery. We believe that the consensus recommendations presented in this manuscript represent reasonable statements about the state-of-the-art in three-dimensional delineation of the various node levels in the node-negative neck. These recommendations have been endorsed by major European and North American cooperative groups in radiation oncology. The node-positive neck and the post-operative neck present additional complexities; although some related alterations to the consensus guidelines are discussed in this manuscript, further refinement definitely will be needed in the future. In the meantime, as IMRT for head and neck tumors is still in its infancy, generous delineation of the target volume might well be prudent.

Implementation of these guidelines in the daily practice of radiation oncology should contribute to reduced treatment variations from patient to patient and help to conduct multi-institutional clinical trials or retrospective studies. Lastly, although guidelines are designed to apply to the vast majority of patients, there will always be individual cases for which sound reasons preclude their use. More than ever, oncologic knowledge, experience and judgment are prerequisites for appropriate use of the recommendations proposed in this manuscript.

References

[1] Byers RM, Weber RS, Andrewa T, McGill D, Kare R, Wolf P. Frequency and therapeutic implications of skip metastases in the neck from squamous carcinoma of the oral tongue. Head Neck 1997;19:14–19.
[2] Chao KS, Wippold FJ, Ozyigit G, Tran BN, Dempsey JF. Determination and delineation of nodal target volumes for head-and-neck cancer based on patterns of failure in patients receiving definitive and postoperative IMRT. Int J Radiat Oncol Biol Phys 2002;53(5):1174–84.
[3] Chao KS, Ozyigit G, Tran BN, et al. Patterns of failure in patients receiving definitive and postoperative IMRT for head-and-neck cancer. Int J Radiat Oncol Biol Phys 2003;55:312–21.
[4] Chong VF, Fan YF, Khoo JB. Retropharyngeal lymphadenopathy in nasopharyngeal carcinoma. Eur J Radiol 1995;21:100–5.
[5] Chua DTT, Sham JST, Kwong DLW, Au GKH, Choy DTK. Retropharyngeal lymphadenopathy in patients with nasopharyngeal carcinoma. A computed tomography-based study. Cancer 1997;79:869–77.
[6] Clayman GL, Frank DK. Selective neck dissection of anatomically appropriate levels is as efficacious as modified radical neck dissection for elective treatment of the clinically negative neck in patients with squamous cell carcinoma of the upper respiratory and digestive tracts. Arch Otolaryngol Head Neck Surg 1998;124:348–52.
[7] Eisbruch A, Foote RL, O'Sullivan B, Beitler JJ, Vikram B. Intensity-modulated radiation therapy for head and neck cancer: emphasis on the selection and delineation of the targets. Semin Radiat Oncol 2002;12(3):238–49.
[8] Dawson LA, Anzai Y, Marsh L, et al. Patterns of local-regional recurrence following parotid-sparing conformal and segmental intensity-modulated radiotherapy for head and neck cancer. Int J Radiat Oncol Biol Phys 2000;46(5):1117–26.
[9] Gregoire V, Coche E, Cosnard G, Hamoir M, Reychler H. Selection and delineation of lymph node target volumes in head and neck conformal radiotherapy. Proposal for standardizing terminology and procedure based on the surgical experience. Radiother Oncol 2000;56(2):135–50. Review.
[10] Hamoir M, Desuter G, Gregoire V, Reychler H, Rombaux P, Lengele B. A proposal for redefining the boundaries of level V. Is dissection of the apex of level V necessary in mucosal cell carcinoma of the head and neck. Arch Otolaryngol Head Neck Surg 2002;128(12):1381–3.
[11] Levendag P, Braaksma M, Coche E, et al. Rotterdam and Brussels CT-based neck nodal delineation compared to the surgical levels as defined by the American Academy of Otolaryngology—Head and Neck Surgery. Int J Radiat Oncol Biol Phys 2003; in press.
[12] McLaughlin MP, Mendenhall WM, Mancuso AA, et al. Retropharyngeal adenopathy as a predictor of outcome in squamous cell carcinoma of the head and neck. Head Neck 1995;17:190–8.

[13] Martinez-Monge R, Fernandes PS, Gupta N, Gahbauer R. Cross-sectional nodal atlas: a tool for the definition of clinical target volumes in three-dimensional radiation therapy planning. Radiology 1999;211: 815–28.

[14] Nowak PJ, Wijers OB, Lagerwaard FJ, Levendag P. A three-dimensional CT-based target definition for elective irradiation of the neck. Int J Radiat Oncol Biol Phys 1999;45:33–9.

[15] Robbins KT, Medina JE, Wolfe GT, Levine PA, Sessions RB, Pruet CW. Standardizing neck dissection terminology. Official report of the academy's committee for head and neck surgery and oncology. Arch Otolaryngol Head Neck Surg 1991;117:601–5.

[16] Robbins KT. Integrating radiological criteria into the classification of cervical lymph node disease. Arch Otolaryngol Head Neck Surg 1999; 125:385–7.

[17] Robbins KT, Clayman G, Levine PA, et al. Neck dissection classification update: revisions proposed by the American Head and Neck Society and the American Academy of Otolaryngology—Head and Neck Surgery. Arch Otolaryngol Head Neck Surg. 2002;128(7): 751–8.

[18] Rouvière H. Anatomie humaine descriptive et topographique, 6th ed. Paris: Masson et Cie; 1948. p. 226–30.

[19] Som PM, Curtin HD, Mancuso AA. An imaging-based classification for the cervical nodes designed as an adjunct to recent clinically based nodal classifications. Arch Otolaryngol Head Neck Surg 1999;125: 388–96.

[20] Wijers OB, Levendag PC, Tan T, et al. A simplified CT-based definition of the lymph node levels in the node negative neck. Radiother Oncol 1999;52(1):35–42.