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Assessment of patency of the internal jugular vein following neck dissection and microvascular flap reconstruction by power Doppler ultrasound

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Abstract

The objective of this study was to assess patency of the internal jugular vein following modified radical or selective neck dissection and microvascular flap reconstruction by power Doppler ultrasound and its impact on free flap survival. In 23 patients who underwent selective or modified radical neck dissection and microvascular flap reconstruction the patency of the internal jugular vein was examined by power Doppler ultrasound on the first post-operative day and after follow-up of at least four months. On the first post-operative day in one patient partial thrombosis was found, while in the other 22 patients the internal jugular vein was normal patent. During follow-up in 17 (74 per cent) patients a normal patent internal jugular vein was found, while partial and complete thrombosis were found in three (13 per cent) patients each. On the first post-operative day 22 of the 23 (96 per cent) free flap veins were visualized. There was no free flap loss during follow-up. Power Doppler ultrasound is a valuable diagnostic technique for determination of internal jugular vein patency and may be useful as screening method or in case of clinical suspicion of thrombosis to determine internal jugular vein patency. Late internal jugular vein thrombosis may probably not effect free flap survival due to neovascularization.

Key words: Neck; Nepolasm Metastasis; Surgical Treatment, Operative; Jugular Veins; Vascular Patency; Ultrasonography, Doppler

Introduction

The classical radical neck dissection was described by Crile in 1906.[1] For a long time it has been the standard procedure for managing lymph node metastases of head and neck squamous cell carcinoma and it is still used when there is major nodal involvement in the neck. To diminish morbidity associated with radical neck dissections, modified radical and selective neck dissections have been developed that preserves structures like the accessory nerve, the internal jugular vein and/or the sternocleidomastoid muscle.[2] In selective neck dissections only lymphatic tissue in levels with the highest risk for metastases of a certain primary tumour is resected, e.g. anterolateral neck dissection (level I to IV).[3] Large vein preservation is important when microvascular free grafting is contemplated. Microvascular free-tissue transfers enable a one-staged transfer of an adequate and sufficient amount of tissue required for reconstruction of virtually all major head and neck defects. Despite the obvious advantages of free tissue reconstruction, there remains the risk of vascular compromise resulting in complete loss of the flap. A frequently used recipient vein in the head and neck is the internal jugular vein. The use of larger-calibre vessels like the internal jugular vein have reduced the number of anastomotic failures. Free flap success rates have risen to greater than 90 per cent in large series.[4–7]

Survival of free flaps is dependent on adequate blood supply. Venous occlusion is the most common cause of flap failure. Venous thrombosis results from a disturbance of normal blood flow with subsequent activation of coagulation mechanism. Activated

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clotting factors collect in areas of sluggish or turbulent blood flow, thereby precipitating platelet aggregation. This, in turn, initiates the thrombotic process.[8] During neck dissection, the blood flow in the internal jugular vein is disturbed by skeletonization, multiple ligatures and microvascular anastomosis. Therefore, theoretically, internal jugular veins in patients undergoing microvascular reconstruction are prone for thrombosis and subsequently free flap loss.

Because venous occlusion is frequently incomplete, clinical symptoms are not always present. Several techniques are available for diagnosing internal jugular vein thrombosis, including angiography, CT, MRI and scintigraphy. Major disadvantages of these techniques are their invasiveness, their static information, radiation exposure or logistic problems. Doppler ultrasound did not have these disadvantages and moreover its parameters of the internal jugular vein in normal subjects showed an adequate grade of reproducibility.[9]

In previous reported studies, patency rates of 70–100 per cent were found using several imaging techniques, like retrograde venography, CT, MRI, Doppler or Doppler ultrasound.[10–20] Besides the different techniques, all examinations were performed in a great variety and range of postoperative time points.

Doppler ultrasound (duplex) combines conventional ultrasound (B-mode, gray scale), which measures vessel wall diameters and the anatomic orientation of adjacent tissue structures with Doppler, which measures flow by the Doppler principle. Color duplex techniques are based on the estimation of the mean Doppler frequency shift. Recently, a method of Doppler technique was described that is based on estimating the integrated Doppler power spectrum: i.e. power duplex. Whereas frequency as measured by colour duplex techniques is determined by the velocity of red blood cells (reflectors), the power depends on the concentration of reflectors moving at a velocity above cut-off (filter) level with sampling volume. Power duplex is even more sensitive in detecting slow blood flow as compared to colour duplex. Another advantage of power duplex over colour duplex is that it is less sensitive to the angle between flow direction and ultrasound beam.[21,22] Power Doppler ultrasound of the internal jugular vein after neck dissection has not been described previously. Power Doppler ultrasound is a highly accurate test in excluding an isolated deep venous thrombosis of the calf: sensitivity of 100 per cent, specificity of 79 per cent, positive predictive value of 71 per cent and negative predictive value of 100 per cent.[23]

The objective of this study was to examine the incidence of internal jugular vein thrombosis in head and neck cancer patients undergoing selective or modified radical neck dissection type II (sparing of accessory nerve and internal jugular vein) and microvascular free flap reconstruction using power Doppler ultrasound one day post-operatively and once at follow-up. Furthermore, to investigate the clinical value of power Doppler ultrasound findings, these findings were correlated with the clinical outcome of the microvascular free flap reconstruction.

Materials and methods

Inclusion criteria for this study were excision of a primary squamous cell carcinoma of the head and neck with en bloc neck dissection, preservation of the internal jugular vein for microvascular anastomosis, dissection of the complete jugular chain of nodes as part of a selective or modified radical neck dissection, and reconstruction by microvascular soft-tissue flap.

A consecutive series of 23 patients was thus compiled and examined for internal jugular vein and free flap vein patency. There were 15 males and eight females with a mean age of 60 years (range 40–73 years). The primary tumours were squamous cell carcinomas in the oral cavity ($n = 8$), oropharynx ($n = 13$) and hypopharynx ($n = 2$). Neck staging according to the UICC Classification of Malignant Tumours[24] was N0 in 11 patients, N1 in five patients, N2b in two patients, N2c in four patients, and one patient had a recurrent oropharyngeal carcinoma without clinical lymph node metastases in the neck.

Surgical procedures included composite resection (oral and oropharyngeal excisions) in 21 patients, pharyngectomy in one patient and total laryngopharyngectomy in one patient each. In 21 patients a modified radical neck dissection type II (levels I–V) was performed, whereas the remaining two patients had an anterolateral neck dissection (levels I–IV). The spinal accessory nerve was preserved in all cases and the sternocleidomastoid muscle was only preserved in two patients who underwent an anterolateral neck dissection. During surgery the facial vein and the other side-branches of the internal jugular vein were ligated.

In 20 patients the defect was reconstructed with a free fasciocutaneous radial forearm flap and in three patients a free myocutaneous rectus abdominis flap was used. All free flap veins were anastomosized end to side on the internal jugular vein and only one vein was used in each case. In all cases, the patency of the internal jugular vein was confirmed intraoperatively by venotomy before anastomosis and by palpation at the end of the procedure.

Twenty (87 per cent) patients received post-operative radiotherapy as part of their combined treatment. The three other patients were not irradiated post-operatively: one patient had no indication for radiotherapy, one patient had a post-radiotherapy recurrence and one patient had a probably radiotherapy-induced hypopharyngeal carcinoma.

Radiotherapy was delivered by a linear accelerator using 6-MV photons. Generally, the initial target volume encompassed the entire surgical bed and all nodal areas of the neck and was treated with two opposing lateral fields and an anterior–appositional photon field to treat the lower neck nodes when

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TABLE I
PATIENTS' CHARACTERISTICS AND RESULTS OF POWER DOPPLER ULTRASOUND

			Tumour		Surgery			1 day post-operative		Follow-up	
Patient Number	Sex	Age	Site	TNM stage	Neck dissection	Free flap	Radiotherapy dose (cGy)	Internal jugular vein thrombosis	Peak flow velocity (cm/s)	Months postoperative	Internal jugular vein thrombosis
1	f	71	Oropharynx	T3N0	Modified radical	FRFF	5500	No	61	12.8	No
2	m	71	Oral cavity	T2N2b	Modified radical	FRFF	6250	No	30	12.5	Partial
3	m	40	Oropharynx	T3N2c	Modified radical	FRAF	6750	No	66	11.9	Partial
4	f	65	Oropharynx	rec	Modified radical	FRAF	4000*	No	60	12.7	No
5	f	55	Oral cavity	T3N0	Modified radical	FRFF	4140	No	80	13.6	No
6	m	65	Oral cavity	T3N0	Supraomohyoid	FRFF	5500	No	13	15.0	No
7	m	72	Oropharynx	T2N2c	Modified radical	FRFF	6500	Partial	14	16.3	No
8	m	57	Oropharynx	T3N2b	Modified radical	FRFF	5500	No	10	10.6	Complete
9	m	47	Oropharynx	T2N1	Modified radical	FRFF	5500	No	10	12.9	No
10	m	54	Oral cavity	T3N1	Modified radical	FRFF	7000	No	10	15.4	No
11	m	65	Oropharynx	T3N0	Modified radical	FRFF	5500	No	40	9.6	No
12	f	53	Oral cavity	T3N0	Modified radical	FRFF	6750	No	50	9.2	Complete
13	f	62	Oropharynx	T3N0	Anterolateral	FRFF†	6750	No	40	12.0	No
14	m	68	Oral cavity	T3N2c	Modified radical	FRFF	6250	No	40	9.8	No
15	f	50	Oropharynx	T4N2c	Modified radical	FRAF	6500	No	48	6.9	No
16	m	65	Hypopharynx	T3N0	Modified radical	FRFF	5500	No	135	6.5	No
17	m	48	Oral cavity	T3N0	Modified radical	FRFF	5500	No	18	7.8	Partial
18	f	70	Oropharynx	T2N1	Modified radical	FRFF	5500	No	29	7.2	No
19	m	73	Oropharynx	T3N0	Modified radical	FRFF	5500	No	32	6.4	No
20	m	57	Oropharynx	T3N1	Modified radical	FRFF	5000	No	34	6.9	No
21	m	65	Hypopharynx	T3N1	Modified radical	FRFF	4000*	No	105	4.8	No
22	m	57	Oropharynx	T2N0	Modified radical	FRFF†	–	No	66	6.4	Complete
23	f	54	Oral cavity	T2N0	Modified radical	FRFF	NA	No	19	5.5	No

rec: recurrence; FRFF: free fasciocutaneous radial forearm flap; FRAF: free myocutaneous rectus abdominis flap; NA: not available. *Previous radiotherapy; †Re-exploration.

indicated. No clinical signs of recurrent disease were found in any patient during follow-up. The patients' characteristics are summarized in Table I.

Patency of the internal jugular vein on the side of microvascular anastomosis was examined immediately post-operatively (day 1) and after a follow-up of at least four months after completion of therapy. The mean follow up time was 10.1 months after surgery (range 4.8 to 16.3 months). The complete internal jugular vein was examined from the clavicle to the skull base by power Doppler ultrasound with a 7.5 MHz linear transducer (Acusan, 128). The findings of power Doppler ultrasound were defined as patent, partial thrombosis or complete thrombosis (i.e. occlusion). Complete thrombosis was defined as visualization of a thrombus in an incompletely compressible vein and absence of spontaneous blood flow, absence of characteristic frequency spectrum of Doppler velocimetry and absence of phasicity of blood flow with respiration. In partial thrombosis, a thrombus was visualized but some (low) blood flow was seen. In addition, peak flow velocity (cm/s) was measured.

Results

On the first post-operative day, 22 of the 23 internal jugular veins were normal patent, whereas in one (patient 7) a partial thrombosis of the internal jugular vein was found by power Doppler ultrasound. Peak flow velocity in the internal jugular vein ranged from 10 to 135 cm/s (mean 44 cm/s). Clinically, free flap vascular problems occurred in two patients: in patient 13 (on the first post-operative day) and in patient 22 (on the second post-operative day), re-exploration of the anastomosis was performed during which a normal patent internal jugular vein was found as was shown by power Doppler ultrasound. In patient 22, thrombosis of the free flap vein was found during re-exploration, while a low flow in the flap vein was found by power Doppler ultrasound previously.

TABLE II
REPORTED STUDIES ON INTERNAL JUGULAR VEIN PATENCY AFTER NECK DISSECTION

Study	Technique	Follow-up	Normal patent (per cent)
Fisher *et al.* 1988[10]	CT	2–4 weeks	10/13 (77)
Docherty *et al.* 1993[11]	Colour Doppler ultrasound	6–97 months	24/32 (75)
Cotter *et al.* 1994[12]	CT/MRI	11 days–113 weeks	68/79 (86)
Lake *et al.* 1994[13]	Doppler ultrasound	> 4 weeks	34/35 (97)
Zohar *et al.* 1995[14]	Doppler/Doppler ultrasound	2 months–22 years	27/31 (87)
Leontsinis *et al.* 1995[15]	Retrograde venography	< 90 days	19/27 (70)
Quraishi *et al.* 1997[16]	Doppler ultrasound	54–558 days	65/69 (94)
Wax *et al.* 1997[17]	Doppler ultrasound	> 54 days	25/27 (93)
Brown *et al.* 1998[18]	CT	1–2 weeks	25/29 (86)
Katou *et al.* 1998[19]	CT	51–107 days	25/25 (100)
Prim *et al.* 2000[20]	Doppler ultrasound	1 + 3 months	54/54 (100)
Present study	Power Doppler ultrasound	1 day	22/23 (96)
Present study	Power Doppler ultrasound	4.8–16.3 months	17/23 (74)

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During follow-up in 17 (74 per cent) patients, a normal patent internal jugular vein was found. Partial and complete thrombosis of the internal jugular vein were observed by power Doppler ultrasound in three (13 per cent) patients each.

No patient with thrombosis of the internal jugular vein developed oedema of the head and neck. There was no free flap loss during long-term follow-up (for patient characteristics see Table I).

Internal jugular vein thrombosis (partial or complete) as found by power Doppler ultrasound occurred in three of 11 (27 per cent) N0, none of five (0 per cent) N1, two of two (100 per cent) N2b and one of four (25 per cent) N2c staged necks. All patients except one underwent radiotherapy. Five of the six patients who developed thrombosis were irradiated.

Discussion

Patients with carcinoma are well-known to be predisposed to the development of a hypercoaguability state. This is partly due to increased platelet count, together with enhanced platelet adhesiveness. Cancer patients have elevated levels of anti-haemophilic globulin (factor VIII) as well, which also may account for their propensity towards post-surgical clot formation. Unavoidable manipulation of the internal jugular vein associated with performance of a modified radical neck dissection preserving the internal jugular vein may aggravate this tendency.[8,15] During anaesthesia, systemic blood pressure often decreases and hypotension is also not uncommon in the immediate post-operative phase. Circulatory changes of this nature are theoretically significant, especially when considered together with other factors which affect laminar flow, such as venous narrowing. The internal jugular vein may be narrowed due to extrinsic compression by a myocutaneous flap,[10,12,18] an organizing haematoma, seroma or early fibrosis[15] or locoregional recurrence.[12] Thrombosis may occur due to major wound sepsis or fistula formation.[15] Also, radiotherapy in addition to modified radical neck dissection, affects patency of the internal jugular vein.[11,14] No relationship has been found between lymph node metastases in the neck and internal jugular vein thrombosis.[18] In our study the number of patients was too small for reliable statistical analysis of the relation between nodal status and internal jugular vein thrombosis. Because only one patient was not irradiated and no tumour recurrence occurred, no conclusions concerning effect of radiotherapy and recurrence on internal jugular vein patency can be drawn from our study.

Considering all these risk factors, it is not surprising that internal jugular vein thromboses can occur after modified radical neck dissection in neck and neck cancer patients. The fact that after modified radical neck dissection type II the patency of the internal jugular vein cannot always be preserved, is important when microvascular free flap reconstruction is contemplated.

Fisher *et al.*[10] were the first to report thrombosis of the internal jugular vein after modified radical neck dissection. Ten of 13 (77 per cent) patients who underwent pre-operative and post-operative contrast-enhanced CT scans had patent veins. Others found patency of the internal jugular vein in 70–100 per cent, using retrograde venography, CT, MRI, Doppler or (colour) duplex on different time points ranging from weeks to years post-operatively[12–16,19,20] (see Table II).

Qurashi *et al.*[16] determined the incidence of internal jugular vein thrombosis after 100 modified radical neck dissections using duplex scanning. During the first four post-operative days, internal jugular vein partial or complete thrombosis was found in 24.7 per cent, and from post-operative days five to 14, in 26.4 per cent. At follow-up (at least three months) only 5.8 per cent remained thrombosed, suggesting recanalization. No effect of pre-operative radiotherapy on internal jugular vein patency was found. In another study of the same group,[17] the incidence of internal jugular vein thrombosis in 27 patients undergoing modified radical neck dissection and microvascular reconstruction was determined using Doppler ultrasound. From post-operative days one to four, 20 per cent and from days five to 14, 22.7 per cent of the internal jugular vein were thrombosed. On follow-up (at least three months) internal jugular vein thrombosis was found in only five per cent. One free flap was lost secondary to massive infection. It is remarkable that despite internal jugular vein thrombosis in the immediate post-operative period free flaps (with outflow through the facial vein) survived. The authors suggest limitations of Doppler ultrasound to detect minimal flow in the internal jugular vein. Conventional Doppler ultrasound does not seem to be suitable for the determination of the patency of the internal jugular vein, because no clear correlation with the clinical outcome has been found. Power Doppler ultrasound can detect low blood flow. Last-generation power Doppler systems have an improved sensibility to low flow volumes. Power Doppler ultrasound has been shown to detect thrombosis elsewhere in the human body reliably.[23]

On the first post-operative days, power Doppler ultrasound examination of the internal jugular vein can be difficult, because of oedema and (staple) sutures. At follow-up, scar tissue may hamper the examination. In this study, the internal jugular vein could be visualized in all examinations.

A wide range of peak flow velocity values (10–135 cm/s) were measured on the first post-operative day in our study. In the only patient with partial thrombosis, a low peak flow velocity was found. Although in other patients with similar low peak flow velocity no thrombosis was detected, low peak flow velocity may be one of the risk factors for development of thrombosis. Therefore, the clinical value of peak flow velocity measurements remains unclear. Prim *et al.*[20] found mean peak flow velocity values in patent internal jugular veins of 22–36 cm/s after modified radical neck dissection.

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In this study at follow-up in 13 per cent a partial thrombosis and in 13 per cent a complete internal jugular vein thrombosis were found. An increased incidence of thrombosis during follow-up as found in our study is different from other studies in which a decrease in thrombosis rate over time due to recanalization is suggested.[17,18] It is important to realize the risk of internal jugular vein thrombosis after modified radical neck dissection and its potential negative effect on microvascular free flap reconstruction. The benefits of internal jugular vein preservation are realized only if patency is maintained. Internal jugular vein thrombosis harbours the risk of complete loss of the free flap. If (complete) internal jugular vein thrombosis is found soon after its development, re-exploration may save the viability of the free flap. Despite narrowing or occlusion of the internal jugular vein, microvascular free flaps may survive.[11,13] Survival of free flaps despite internal jugular vein thrombosis during follow-up may be caused by neovascularization.

In conclusion, power Doppler ultrasound is a valuable diagnostic technique for determination of internal jugular vein patency, because of its capacity to detect slow blood flow. Power Doppler ultrasound may be useful as a screening method or in case of clinical suspicion of thrombosis to determine internal jugular vein patency. Power Doppler ultrasound can be used in the first post-operative days and during follow-up. Its clinical value remains to be substantiated.

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