The Nijdam Voice Prosthesis: A Self-retaining Valveless Voice Prosthesis for Vocal Rehabilitation after Total Laryngectomy

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INTRODUCTION

Although non-shunt oesophageal voice rehabilitation was the standard for laryngectomees for many years, this has gradually been changing over the past 15 years. Airway shunting to the digestive tract, initially with unprotected shunting techniques (1, 2) allowed fairly natural, fluent speech for the majority of patients. A major drawback was the occurrence of aspiration (of saliva, fluid and food substances) on the one hand and secondary stenosis on the other. The introduction of the one-way valved silicone prosthesis (3) was a major step forward; it prevented aspiration as well as premature closure of the shunt. Over the past 15 years, several (non-)self-retaining voice prostheses (VP) and low-pressure modifications have been developed for postlaryngectomy voice rehabilitation (3-8). Almost all low-pressure devices presently available have a high voice rehabilitation success rate after total laryngectomy, which ranges from 60-90% (9-11). These different rates are only partly related to the device used. More often there will be a relationship with the extent and technique of surgery. Better results are achieved with primary placement than with secondary placement (12, 13). The majority of patients benefit from pharyngeal plexus neurectomy or myotomy of the cricopharyngeal and lower pharyngeal muscles at primary operation (14-16). In addition, the experience and postoperative concern of both the surgeon and the speech therapist are likely to effect the final result, as well as patient-related factors such as manual dexterity, intelligence, psychological and sociological factors (17, 18).

Vocal rehabilitation is one of the most important factors that defines the quality of life after total laryngectomy. Therefore, continuous efforts to improve rehabilitation of the lost voice after total laryngectomy are mandatory and should also be directed towards improving existing voice prostheses or developing new ones. Prosthesis-related factors such as aerodynamic properties, early material deterioration, dysfunction of the valve mechanism and a tendency to induce tissue reactions, should all be constantly reconsidered for improvement.

The ideal voice prosthesis, which should be bio-compatible, self-cleaning, have a low resistance, be resistant to fungi, leakproof and suitable for primary placement with an unlimited device lifetime, does not exist yet.

We have tried the newly developed, valveless Nijdam voice prosthesis extensively. It comes closer to the above-mentioned goals. Our experience is presented in this paper.

Development and description of the Nijdam voice prosthesis

From long-term investigations on the Groningen VP, it has become obvious that the device lifetime is limited by the ingrowth of fungi in the oesophageal part of the prosthesis (22). This decreases the flexibility of the silicone elastomer and leads to increased
rigidity of the material. Problems mainly occur in the
valve-bearing part of the device and cause leakage
through the prosthesis or increase the airflow resis-
tance; both malfunctions indicate the end of the life
of the device. Since 1984 efforts have been made to
develop a valveless voice prosthesis.

The Nijdam VP (Fig. 1) is made of medical grade
silicone elastomer. It consists of a bifanged hollow
shaft of variable length and diameter. Two shaft
diameters (standard 7 mm and optional 8 mm) are
available and there are five shaft lengths (4, 5, 6, 7 and
8 mm) in order to enable proper adjustment to the size
of the fistula and the variable thickness of the tracheo-
esophageal wall. The oval tracheal flange is equipped
with a silicone string and a small perforation, both
used for introduction (Fig. 2). The length of the shaft
of the prosthesis is printed on the tracheal flange.

In this newly developed silicone voice prosthesis,
the round oesophageal flange has open communica-
tion with the shaft of the prosthesis. The oesophageal
flange covers the oesophageal end of the tracheo-
esophageal fistula like an umbrella. The rim of the
oesophageal flange maintains slight pressure against
the oesophageal mucosa and forms a barrier to pre-
vent leakage. Thus the barrier mechanism is partially
prosthetic and partially biological. As Candida de-
contamination does not influence the flexibility of the
mucosa in the oesophagus, it was estimated that the
ingrowth of the fungus in the material of the prosth-
esis would cause few problems with the occlusive
mechanism.

As voice production is initiated the stoma is oc-
cluded and the intratracheal pressure rises with at-
temptsed expiration. The oesophageal flange of the
prosthesis is lifted off the oesophageal mucosa and air
escapes into the oesophagus. This initiates vibrations
of the pharyngo-oesophageal (PE) segment needed
for speech (Fig. 3). Proper adjustment of the length
of the shaft to the thickness of the tracheo-
esophageal wall is mandatory, because a relatively
long shaft may cause leakage, while a relatively short
shaft may result in an increase in airflow resistance. It
is our experience that proper adjustment is possible
without the need for a measuring device.

The Nijdam VP is interchangeable with other in-
dwelling voice prostheses, such as the low-pressure
Groningen VP, Blom-Singer VP (Ø 21 French) and
the Provox VP.

**Surgical technique**
The surgical technique for primary as well as sec-
ondary placement is similar to that of the low-pres-
sure Groningen VP and Provox VP, which has been
described elsewhere (19, 20).

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*Fig. 1. The valveless Nijdam voice prosthesis.*

*Fig. 2. The tracheal flange can be collapsed with the aid of
the introduction string to promote easy passage of the
prostheses through the fistula. The size of the prosthesis is
printed on the tracheal flange.*

*Fig. 3. The barrier mechanism of the Nijdam voice pros-
thesis. Artist's representation of the in vivo situation. The
arrow indicates the airflow during speech that lifts the
oesophageal flange (prosthetic part of the valve) away from
the slightly depressed oesophageal mucosa (biological part
of the valve).*
and adapted at our clinic.

In 1990, in addition to the low-pressure Groningen VP, in which the valve mechanism was altered from a straight into a semicircular slit, thus reducing the airflow resistance by 50% (7). In 1990, in addition to the low-pressure Groningen VP, the Nijdam VP and Provox VP were introduced and adapted at our clinic.

All prosthesis replacement procedures performed at our outpatient clinic between January 1991 and July 1993 were evaluated prospectively. During the study period, 220 Nijdam VP were replaced in 74 evaluable patients. After every replacement, a standard form was completed stating replacement indication, device lifetime, size of the old and new prostheses, complications of the replacement procedure and the local appearance of the fistula.

Seven laryngectomees who were using the Nijdam prosthesis, were selected at random for intratracheal pressure measurements. The mean device lifetime of the Nijdam prosthesis at the time of measurement was 35 days (range 17–48 days). The laryngectomees were asked to produce a sustained vowel /a/ at varying sound pressure levels, ranging from very soft to very loud. The intratracheal pressure with its corresponding sound pressure level were measured at a mouth–microphone distance of 30 cm. The pressure sensing catheter used to measure the intratracheal pressure was sealed by the patient between the tracheostoma and an occluding finger while producing a sustained /a/. The catheter was connected to a self-designed pressure transducer. The sound level was measured using a sound level meter (Brüel & Kjær, type 2225). From these measurements the intratracheal pressure at a sound pressure level of 70 dB was calculated by interpolation. A sound pressure level of 70 dB at 30 cm mouth–microphone distance is equal to 67 dB at 50 cm distance, which is the mean intensity of the comfortable loudness of tracheo-oesophageal shunt speech.

RESULTS

No complications were encountered with the primary tracheo-oesophageal puncture and placement of the Nijdam VP.

The average device lifetime of the Nijdam VP, based on 220 replacements, was 19 weeks (standard deviation 21.7 weeks, range 1–156 weeks). The most frequent replacement indication was leakage through the voice prosthesis (50%); leakage around the voice prosthesis occurred in only 5% of replacements. Increased airflow resistance was the replacement indication in 45% of the replacements. The aspect of the fistula was normal in the majority of patients. Minor local complications consisted of granulation tissue (12%) and hypertrophic scar tissue formation (10%) which could be treated easily with cauterisation or local resection. Sometimes, a longer voice prosthesis was inserted to avoid this local problem, but it never resulted in permanent removal of the prosthesis.

Complicated removal was often associated with granulation tissue or hypertrophic scar tissue formation. Sometimes, a narrow tracheostoma also caused problems. Loss of the prosthesis and removal under general anaesthesia were classified under the compli-
cated removals. Complicated insertion was often related to hypopharyngeal or oesophageal stenosis. To find the tract, sometimes retrograde insertion of a nasogastric tube was necessary as a first step to replace a prosthesis. Retrograde insertion was included among the complicated insertions. In some cases the introduction string broke during insertion or insertion had to be carried out under general anaesthesia. Complicated removal occurred in 3.6% and complicated insertion in 11.5% of replacements. Replacement complications were mostly of a minor nature. Replacement under general anaesthesia was necessary in 2.3% of our patients, all due to hypopharyngeal or tracheostoma stenosis.

The intratracheal pressure of a sustained /a/ of 70 dB at a distance of 30 cm from the mouth was found to be 4.3 kPa (range 2.8–6.1 kPa).

Subjectively the speech rehabilitation success rates with the Nijdam VP were comparable with those of the Groningen VP (10).

DISCUSSION

The development of the low-resistance, valveless Nijdam VP has brought us some steps closer to an ideal VP. The innovative design of this flexible device, that can be streamlined for easy introduction, with a completely new barrier mechanism, more resistant to Candida-induced malfunctioning, means an improvement over existing voice prostheses.

The average device lifetime of the Nijdam VP (n = 220) of 19 weeks is significantly longer than the 15.8 weeks that we found for the Groningen VP (n = 453) or the 13 weeks of the Provox VP (n = 172). In our opinion, this is related to the valveless design of the Nijdam VP, with a barrier mechanism that is less sensitive to Candida-induced malfunctioning. Deterioration caused by Candida species is the most important factor for reducing device lifetime (22).

The valveless Nijdam VP is an indwelling device. Indwelling devices require little patient care. This seems to be an advantage, as complications have been reported in association with removal, cleaning and reinsertion of non-indwelling devices by the patient.

Complications of the primary tracheo-oesophageal puncture were not encountered with the Nijdam VP. Replacement of the Nijdam VP is a simple outpatient procedure because it is very flexible. It can therefore be removed easily by carefully pulling it out. Removal of other more rigid voice prostheses in this way should be avoided because it may traumatize the fistula, cause shunt insufficiency and subsequent periprosthetic leakage. Transoral removal of these devices, as well as reinsertion, can cause problems in patients with hypopharyngeal or oesophageal stenosis. This is reflected by the relatively high complication rate reported in the literature of 8% in patients using a Provox VP (5), who needed dilatation under general or local anaesthesia before replacement. Even in patients with moderate hypopharyngeal or oesophageal stenosis, insertion of the flexible, streamlined Nijdam VP did not cause any problems. With transtracheal–transoral replacement, the oesophageal flange is always intra-oesophageal. There is no need for repeated X-ray examinations to check the proper positioning of the oesophageal flange, as is recommended for the new Blom-Singer VP with transtracheal-gel-cap insertion (21). Anterior dislodgement and aspiration of a Nijdam VP have not been observed in our series.

The “umbrella effect” of the Nijdam VP, in which the oesophageal flange protects the oesophageal end of the fistula from leakage around the prosthesis, may explain why leakage around the prosthesis as a replacement indication only occurred in 5% of the Nijdam VP replacements. This compares favourably with the reported 20.5% of Provox users who need some sort of treatment because of widening of the fistula and leakage around the voice prosthesis (11). Occasionally, a Nijdam VP can be used to replace a Groningen VP or a Provox VP if there is leakage around the device and temporary removal with reinsertion of the prosthesis after shrinkage of the fistula is considered to be too long-winded. Gax-collagen injection as a treatment option to correct an enlarged fistula is said to have good results as well (23), although the advised tolerance test does seem to interfere with the acute nature of leakage around a voice prosthesis.

Although the intratracheal pressure during voice-prosthesis-assisted tracheo-oesophageal speech is only partly caused by the prosthesis itself, it is a strong indicator of the aerodynamic characteristics of a device. We compared the intratracheal pressure of the Nijdam VP to that reported for other shunt valves.

During comfortable speech, the mean intratracheal pressure of the standard Groningen VP (24), the low-resistance Groningen VP (25) and the Provox VP (5) were 9.3 kPa (4.0–16.2 kPa), 3.3 kPa (P97.5 = 2.4 kPa and P75 = 4.6 kPa) and 1.9 kPa (1.0–3.8 kPa), respectively. The airflow-resistance of the Blom-Singer low-pressure VP is comparable with that of the low-resistance Groningen VP (7).

The mean intratracheal pressure of the Nijdam VP was 4.3 kPa (2.8–6.1). This is significantly lower than that of the standard Groningen VP, but the latter is not considered to be a low-resistance VP and should therefore be avoided. When interpreting these data, it should be realized that our measurements were not done immediately after the insertion of a new Nijdam VP.
but after the voice prosthesis had been in situ for an average of 35 days. It has been reported that the intratracheal pressure of the low-resistance Groningen VP increases from 3.3 kPa \( (P_{25} = 2.4 \text{ kPa}) \) and \( P_{97.5} = 4.6 \text{ kPa} \) to 4.7 kPa \( (P_{25} = 2.6 \text{ kPa}) \) and \( P_{97.5} = 8.5 \text{ kPa} \) after three to four months of use \( (25) \).

The aerodynamic characteristics of the Nijdam VP are comparable with those of the low-resistance Groningen VP so it can be considered to be a low-resistance device.

The valveless Nijdam voice prosthesis has advantages over the existing devices: a longer device lifetime, simple replacement procedure, less sensitivity to Candida-induced malfunctioning and infrequent periprosthetic leakage caused by enlarged fistulas. The main disadvantage is the need for some amount of experience with adjusting the shaftlength of the prosthesis so that it conforms with the thickness of the tracheo-oesophageal wall.

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REFERENCES


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