ORIGINAL ARTICLE

„Pushed” monocanalicular intubation in children under general anesthesia with spontaneous ventilation. A preliminary report

Intubation mono-canaliculonasale « poussée » sous anesthésie générale en ventilation spontanée sur les enfants

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KEYWORDS
Epiphora; Congenital nasolacrimal duct obstruction; Dacryostenosis; Lacrimal probing; False passage; Lacrimal surgery; Lacrimal intubation; Monocanalicular

Summary

\textit{Purpose.} — We studied the possibility of placing a new type of monocanalicular nasal intubation under general anesthesia with spontaneous mask ventilation in congenital nasolacrimal duct obstruction.

\textit{Patients and method.} — This was a non-randomized study of consecutive cases using a monocanalicular stent called the “pushed Monoka”. The benefits of anchoring with meatus fixation are similar to the original Monoka device, but the probe guide or introducer is inside the silicone tube. The external diameter of the “pushed Monoka” is 0.96 mm (versus 0.64 mm in the traditional Monoka). There are three lengths: 30, 35, and 40 mm. General anesthesia was administered by inhalation of a halogen gas using a facial mask. The technique was selected by lacrimal exploration to evaluate the extent of the stenosis (simple or complex). The location and freedom of movement of the stent into the inferior nasal meatus was tested using a second lacrimal probe. Only simple stenosis cases with positive metal-to-metal contact were included in the study.

\textit{Insertion technique.} — The introducer pushes the stent into the lacrimal duct. The introducer should be removed from the silicone sleeve very carefully by gently pulling it out, millimeter by millimeter. This action is carried out while paying careful attention to keeping the stent aligned with the major axis of the lacrimal sac. Throughout this phase, the anchoring plug should remain in contact with the lacrimal punctum. Once the introducer is completely removed, the anchoring plug is secured into the vertical canaliculus. A single-use plug inserter was used.

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Results. — Fourteen children (18 sides) with congenital nasolacrimal duct obstruction were consecutively included in the study. The pushed intubations were all performed under general anesthesia with spontaneous ventilation. The average age of the children was 26.2 months (range: 14 to 46 months). The average duration of the procedure, measured between the moment that the facial mask was put into place and the child's awakening (crying, restlessness) was 14 minutes (range: 9 to 27 minutes). The most variable parameter was the use of the venous portal. The introduction of the pushed probe itself required an average 7 minutes (range: 3 to 11 minutes). None of the children showed epistaxis. In general terms, no intraoperative or postoperative complications were noted. The ''pushed Monoka'' tubes were withdrawn during postoperative appointments with a mean intubation duration of 34 days (range: 1 to 59 days). Postoperative success (absence of epiphora, absence of mucous discharge) was achieved in 88% of cases (16/18 sides). The average follow-up was 8.7 weeks (range: 3 to 26 weeks). Complications and side effects were minimal. One stent was withdrawn on day 1 due to a keratitis with respect to the anchoring plug. Three stents were spontaneously lost (16%) between day 2 and day 30. Anterior rhinoscopy found none of the stents in the inferior nasal meatus. These four cases were all considered successful as there was no postoperative epiphora noted.

Conclusions. — Pushed nasolacrimal intubation can be safely utilized under general anesthesia with spontaneous mask ventilation. This technique appears to be a simple and safe alternative to late and very late probing in the treatment of membranous congenital nasolacrimal duct obstruction in children older than 12 months.

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MOTS CLÉS
Larmoiement de l’enfant ; Imperforation lacrymonasale congénitale ; Sondage lacrymal ; Fausse route ; Chirurgie lacrymale ; Intubation lacrymale ; Intubation monocanaliculaire

Résumé
But. — Étudier la possibilité de placer une nouvelle intubation mono-canaliculonasale avec une anesthésie générale en ventilation spontanée dans le traitement des imperforations lacrymonasales congénitales au-delà de l’âge d’un an.
Patients et méthode. — Il s’agit d’une étude non randomisée de cas consécutifs. La sonde employée est une Monoka modifiée : son guide de pose est à l’intérieur du silicone. Le diamètre externe de la sonde est de 0,96 mm (0,64 mm pour les Monoka classiques). Il existe trois longueurs de sonde : 30, 35 et 40 mm. L’anesthésie générale se faisait par inhalation d’un gaz halogéné à l’aide d’un masque facial.
Inclusion. — Le sondage lacrymal appréciait l’étendue de la sténose (simple ou complexe). La liberté de la sonde dans le méat nasal inférieur était testée à l’aide de la deuxième sonde lacrymale. Seules les imperforations muqueuses de la valvule lacrymonasale avec un contact métallique positif ont été incluses dans l’étude.
Mise en place. — La sonde était poussée à l’intérieur des voies lacrymales par le mandrin. Son ablation devait être très précautionneuse. Le mandrin était retiré tout doucement en tirant sur son manchon, millimètre par millimètre. Ce geste s’effectuait en restant toujours dans le grand axe du sac lacrymal. Durant toute cette phase, la tête de fixation devait rester au contact du méat lacrymal. Une fois le guide entièrement retiré, la tête de fixation était engagée dans le canalicule vertical. Un pose clou dilatateur à usage unique était employé.
Complications et effets indésirables. — Une sonde avait été retirée dès j1 en raison d’une kératite ponctuée superficielle en regard de la tête de fixation. Trois sondes (16 %) avaient disparu entre j2 et j30. La rhinoscopie antérieure n’avait retrouvé aucune de ces sondes dans le méat nasal inférieur. Ces quatre cas font partie des succès fonctionnels.
Introduction

The treatment of congenital nasolacrimal duct obstruction in children of over 12 months of age is still controversial. The success rate of nasolacrimal duct probing in non-syndromic cases has been reported to range from 50 to 90% [1]. The reasons for such discrepancies are most likely multifactorial. Historically, the results of nasolacrimal probing have only been correlated in regard to the age of the child at the time of the probing. Some reports have stated that success rates decrease significantly with increasing age at the time of probing [1,2]. However, this conclusion has been contradicted by other series [3—5].

More recently, the importance of another diagnostic consideration other than age at the time of probing has been suggested: namely, the location and complexity of the obstruction [6—8]. The success rate was reported to increase from 33% in complex forms of stenosis to about 90% in the simple form of membranous obstruction (Hasner's membrane impatency) [6]. The child's age at the time of the probing appeared to have little or no impact during the early years in the simple form of obstruction.

Supporters of early office probing (3 to 6 months of age) do not apparently recognize the natural history of spontaneous resolution approaching 90% by 12 months of age [1]. Supporters of late or delayed probing (after 12 months of age) believe that too many cases may be unnecessarily probed at an early age and recognize not only the good success rates achieved with probing under general anesthesia but also the advantage of being able to proceed with other therapeutic options as recognized at the time of the probing such as silastic intubation [4,9—17].

The success rate of nasolacrimal silicone intubation has been reported to be above 90% in many studies [1,18]. While silicone intubation has most commonly been reserved for failed probing, recent studies have indicated excellent results with monocanalicular silicone intubation for the initial correction of congenital nasolacrimal duct obstruction [16,19]. The main criticism concerns the potential for associated trauma to nasolacrimal structures as well as the increased cost in regard to the use of silicone intubation for managing simple forms of congenital nasolacrimal duct obstruction (NLDO).

Most intubation stents are composed of a silicone tube attached at each end by a malleable stainless steel probe guide or flexible Polyetheretherketone (PEEK) thread. Because the probe must be located beneath the inferior turbinate and then drawn out the nostril, they can be termed “pulled” intubations. The recovery of the guide in the nasal cavity, however, can be difficult and can potentially cause significant bleeding. For this reason, “pulled” nasolacrimal silicone intubation requires general anesthesia with mechanical ventilation and laryngeal protection.

Figure 1. The “pushed Monoka”. Monocanalicular stent with anchoring plug for meatic fixation. The probe guide, or introducer, is inside the silicone tube. The external diameter of the silicone tube is 0.96 mm.

An alternative type of intubation stent, a “pushed” form, has been devised in an effort to reduce the complications of “pulled” intubations. This type of stent is characterized by the probe guide or introducer actually placed inside the silicone tube, rather than attached at the end as in conventional “pulled” intubations stents [19]. The silicone is thus pushed into the lacrimal ducts by catheterization (Fig. 1).

The removal of the introducer is then accomplished via an “upper” route thus avoiding the nasal recovery step of “pulled” intubations. Use of a “pushed” intubation method is more similar to a simple probing technique than “pulled” intubation and, in this fashion, can be can faster with use of a general anesthetic permitting use of a face mask with less risk of airway compromise.

In this paper, we report on the use of a “pushed” monocanalicular intubation technique in the treatment of simple Hasner’s membrane obstructions performed under brief general anesthesia with spontaneous ventilation.

Patient and methods

We treated non-syndromic simple congenital nasolacrimal duct obstructions using a single “pushed” monocanalicular nasal intubation in cases that had never been previously probed.

We used a new monocanalicular stent (Fig. 1) called the “pushed Monoka” (PM). The anchoring plug for punctal fixation is similar to the one on the original Monoka, but the introducer is inside the silicone tube. The external diameter of the PM is 0.96 mm (in contrast to 0.64 mm of the...
Patient selection. The lacrimal probe is directed until the nasal floor is reached. Then the probe is carefully removed on a millimeter. Freedom of movement of the probe in the inferior nasal meatus was verified using a second lacrimal probe (metal-to-metal contact).

There are three lengths: 30, 35 and 40 mm.

The steps for the procedure were as follows: anesthesia, selection criteria for "pushed" versus "pulled" stents, technique for "pushed" nasolacrimal intubation, postoperative treatment.

**Anesthesia**

General anesthesia was achieved by inhalation of a halogen gas using a facial mask. All normal precautions were implemented: cardioscope monitoring, monitoring of \( O_2 \) saturation, monitoring of blood pressure by a sphygmomanometer cuff, and intravenous line control.

**Selection criteria for "pushed" versus "pulled" stents**

Nasolacrimal duct probing evaluated the location and complexity of the stenosis. The probe was moved inferiorly until a popping sensation was noted (Hasner’s membrane) and then the nasal floor was reached. To confirm proper passage of the probe beneath the inferior turbinate, a larger smooth probe (Bowman 2/0, for example) was very carefully guided into the lower nasal meatus until a "metal-to-metal contact" was felt (Fig. 2). Only cases with simple stenosis and positive metal contact confirmation were included in the study and all had PM intubations at the time of initial probing. For other more complex cases, a classical "pulled" Monoka was put into place under general anesthesia with mechanically assisted ventilation and laryngeal protection with an endotracheal tube. All such cases were excluded from the present study.

**Technique for "pushed" nasolacrimal intubation**

The upper lacrimal punctum was carefully dilated. The PM was pushed through the upper canaliculus all the way to the "hard stop" or bony contact. While maintaining bony contact, the PM was rotated inferiorly to catheterize the lacrimal sac and the nasolacrimal duct (just as done as for routine probing) until the nasal floor was reached. The appropriate PM model was chosen by adding 5 mm to the distance between the lacrimal punctum to the nasal floor. For example, for a punctum to nasal floor measurement of 25 mm, we chose a 30 mm PM, and so on (Fig. 3).

Removal of the introducer was carried out very carefully. The anchoring plug was secured against the upper lid tissue while carefully extracting the introducer (Fig. 4).

The introducer was removed by gently pulling it from the external section of the tube, millimeter by millimeter. Simultaneously, small rotational movements were made with the introducer, which helped to slide it out from the silastic sleeve. Throughout this phase, the anchoring plug was held in firm contact with the lid tissues.

If the anchoring plug tended to come back out, the PM was then pushed back in until the anchoring plug came back in contact with the punctal meatus (Fig. 5).

Removal of the guide was then continued. Once the introducer was completely removed, the anchoring plug was inserted into the vertical canaliculus using a single-use plug inserter as is done for routine punctual plug insertions.

Halogen gas was then replaced by oxygen until the child awoke and could be safely transported to the recovery room.

**Postoperative treatment**

Eye drops combining neomycin and dexamethasone were instilled three times daily for 7 days. Postoperative examinations were scheduled on day 1, day 7 and day 21 for the removal of the stent and thereafter upon request.

**Results**

Fourteen children (18 sides) with permanent congenital nasolacrimal duct obstruction were included in this study of non-randomized consecutive cases.
"Pushed" monocanalicular intubation under general anesthesia with spontaneous ventilation

The families had received written information on the treatment options and they had given their written consent. The PM procedures all took place under general anesthesia with masked spontaneous ventilation only.

The results are summarized in Table 1. The average age of the children was 26 months (range: 14 to 46 months). The average duration of the operation, measured between the moment that the facial mask was applied and the awakening of the child (crying, restlessness, etc) was 14 minutes (ranging from 9 to 27 minutes). The most variable parameter being the time required for achieving a venous portal (intravenous line). The insertion of the PM itself required 7 minutes (range: 3 to 11 minutes). None of the children showed any epistaxis. No significant intraoperative or postoperative complications were reported.

The PMs were removed during appointments with a mean intubation duration of 34 days (range: 1 to 59 days). Beyond that, the average follow-up was 8.7 weeks (range: 3 to 26 weeks). Postoperative success (absence of epiphora, absence of mucous discharge) was achieved in 88% cases (16/18 sides). One bilateral case has maintained clear but intermittent tearing.

Complications and side effects

A stent was withdrawn on day 1, due to a keratitis with respect to the anchoring plug. The same child’s contralateral PM, however, was well tolerated for 21 days (case No. 6). Three stents had apparently spontaneously dislodged and been lost (16.6%). Anterior rhinoscopy found none of the stents in the inferior nasal meatus.

These three cases were all included in the successful group of cases as there was no evidence of postoperative epiphora.

Two cases of mildly watery eyes with normal examination (fluorescent positive.) persisted throughout the duration of intubation, but the tearing disappeared in both cases following removal of the stent.

Discussion

This paper raises a question as to whether the availability of a “pushed” method of silicone intubation might lead to a change in the treatment paradigm for simple congenital nasolacrimal duct obstruction when an initial probing is done after 12 months of age.

The success rate of “pulled” nasolacrimal intubation is about 90% in most series. This is considered a great advantage by proponents of early nasolacrimal intubation following failed simple probing and irrigation and is often considered the "gold standard" for treatment of these problems [1].

Since studies are so disparate, it is very difficult, however, to accurately compare the success rates of probing
<table>
<thead>
<tr>
<th>Chronological order</th>
<th>Side</th>
<th>Age (months)</th>
<th>Pushed Monoka-length (mm)</th>
<th>Duration of operation (minutes)</th>
<th>Intubation (days)</th>
<th>Epiphora with tube in place</th>
<th>Complications</th>
<th>Results</th>
<th>Follow-up (weeks)</th>
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<tr>
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<td>3 to 26</td>
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</table>
at different age categories, such as early probing: 0 to 12 months; late probing: 12 to 24 months and very late probing: 24 months. Several authors obtained 90% positive outcomes regardless of specific selection criteria [3–5]. Other supporters of late and very late probing, however, did recognize the importance of differentiating between simple and complex stenosis based on information from touch or tactile sensation [6,7,20,21]. In the case of complex stenosis, for example, the success rate for probing was only about 35%, whereas in the simple stenosis category, the success rate remained about 90% even up to 36 months of age at the time of probing [6].

Excluding age as a factor in the success of probing, the location and complexity of the obstruction appears to be another important factor. The boundary between a simple and complex stenosis, however, is not always clear and is dependent on a sense of touch during the probing procedure. Such reliance on tactile sensation for locating a specific site of obstruction, because it is subjective, introduces a bias of selection, which could possibly impact the type of treatment chosen.

Nevertheless, in the present study, we did adopt the selection criteria suggested by Kushner for children of over 12 months of age, as follows:

- in complex stenosis cases and/or failures of simple probing, we automatically selected the "pushed" intubation technique;
- in simple stenosis, however, if the child had never been probed, where previously we chose probing alone with brief general anesthesia, we decided to use the "pushed" intubation technique for all of these cases.

This decision was based on our personal experience that the success rate for late probing alone in a retrospective series of children not previously treated was only 60.8%. The study included 23 consecutive cases in the period from 2004 to 2007 with an average age of 19 months. Hasner's membrane imperforation, was noted using a brief general anesthetic without mechanical assistance. The rate of success, in this series of simple stenosis cases was much lower than reported in other series of late and very late probing (12 to 36 months). Perhaps this reflects on some variation in our subjective classification of these cases as simple rather than complex. However, based on this information as well as on the good results from initial silicone intubation for similar cases reported in other series, we felt that proceeding with the "pushed" intubation in cases with simple obstruction was acceptable.

Reasons for silicone intubation failure

Unlike probing alone, conventional nasolacrimal intubation is largely independent of any selection bias based on the subjective considerations of tactile sensation. It has been the treatment of choice in most series where probing fails. The PM is not recommended, however, in cases of complex stenosis any more than is probing alone [22]. In such instances, we fear that the introducer alone might pass through the stenosis and that the silicone tube might then remain stuck at a point just in front of the obstacle. When in doubt, it is preferable to use a classical "pulled" intubation to the "pushed technique.

The technique of nasolacrimal catheterization (probing, intubation) itself is another potential cause of failure. The catheterization is done blindly. Several endoscopic observations of the inferior nasal meatus may highlight the existence of a submucosal passage in the lateral nasal wall or in the mucosa of the nasal process of the inferior turbinate. The frequency is not well established, but has been reported to be about 11% [15,23,24].

The risk of a false passage is also common to either probing or intubation ("pushed" and/or "pulled"), but the impact on the results is unclear.

In "pulled" nasolacrimal intubation, recovery of the probe guide is often associated with damage to some part of the nasal mucosa. This may correct some false passages, and sometimes this may even go unrecognized by the surgeon [18]. Correction in such cases cannot be expected either with probing alone or with "pushed" intubation as the misinterpretation of the false passage will affect the failure rate in the same proportions. A successful result in such cases requires a mandatory second catheterization. Screening for false passages must be anticipated.

The search for metal-to-metal contact is simple. Its reliability should be more carefully appreciated as this test is sometimes unfairly criticized because of the risk of nasal bleeding.

While nasal endoscopy is probably the most accurate screening method [23–28], this greatly increases the complexity of the procedure to the point that the immediate decision to proceed with classical nasolacrimal intubation makes more sense.

Mucosal scarring is another possible reason for failure. While the stent may have correctly pierced the Hasner's membrane, this still cannot eliminate the possibility of late scarring and subsequent relapse. The success rates are different between intubation and probing alone in these cases. The placement of the silicone tube presumably prevents re-stenosis of the nasolacrimal duct as well as possibly stimulating growth in the diameter of the nasolacrimal bony canal. The success rate of intubations ("pushed" and/or "pulled") for late probing patients appears to be better than late probing alone.

If mucosal scarring is truly a common cause of failure in simple obstructions, then "pushed" intubation should be a useful alternative when utilized for late probing.

Our results are consistent with these assumptions. The success rate of PM (88%) is better than late probing alone (60% in our series) but less than that reported with "pulled" intubation (95%).

Prospective randomized studies with systematic endoscopic examinations will be needed to more fully answer these questions.

Complications of "pushed" intubation

Complications associated with nasolacrimal probing are generally quite low [1,13,17,24,29–33]. The risk of nasal bleeding is very slight if the child's hematologic condition is normal and there is an absence of nasal pathology.
Pulled intubation also carries a risk of bleeding during its nasal phase when extracting the stent introducer. This is dominated by the risk of nasal bleeding.

Pushed intubation was not associated with more mucosal bleeding than simple probing, even though the pushed stent is broader (0.96 mm) than classical lacrimal stents (0.64 mm).

To this can be added complications related to the presence of the silicone intubation.

The adverse effects of PM (corneal erosion, loss of the tube) do not differ in frequency from those reported in several large series of classical Monoka insertion (Table 2) [18,19,34–40].

Assisted probing adapts well to brief general anesthesia with spontaneous ventilation. The waking up period is brief. The need for surveillance during wake-up is reduced.

Use of sedation alone has been reported but we do not have any direct experience with this approach [41,42].

Pulled nasolacrimal intubation requires general anesthesia with mechanically assisted ventilation, it is slower to obtain (IV sleep, oro-tracheal intubation, extubation, awakening). The risk of bleeding is very low but caution warrants protecting the larynx. Classical lacrimonasal intubation often requires the use of morphine and often curare. The use of these anesthetic drugs increases cardiorespiratory risks when using morphine, and allergies when using curare. The awakening is slower and warrants more prolonged “awakening” monitoring in recovery room.

The risk of laryngospasm exists with both of these two types of anesthesia, but it is increased for the general anesthesia with mechanically assisted ventilation alone. It can also be triggered by oro-tracheal intubation, however, either during the introduction of the cannula or during its removal.

The risk of laryngospasm is less important with the laryngeal mask (which can be used with both types of anesthesia). But its air-tightness is more frequently criticized than endotracheal intubation with a low-pressure balloon, particularly when irrigation is included as part of the probing procedure.

The 18 PM cases reported in this series were inserted under general anesthesia with spontaneous mask ventilation with no particular difficulty. The duration of the procedure was increased by less than 7 minutes. We did not observe any particular nasal bleeding. In no case was the postoperative course unreasonably prolonged.

## Conclusions

This preliminary study demonstrates that a “pushed” nasolacrimal intubation can be safely utilized under general anesthesia with spontaneous mask ventilation.

This technique appears to be a simple and safe alternative particularly for late and very late probing in the treatment of membranous congenital nasolacrimal duct obstruction in children older than 12 months.

We look forward to reporting on longer-term follow-up utilizing the PM technique.

## Conflict of interest

B.F. holds the patent for the “pushed Monoka”.

### Table 2

<table>
<thead>
<tr>
<th>Authors</th>
<th>Year</th>
<th>N=</th>
<th>Granuloma of punctum</th>
<th>Canaliculitis</th>
<th>Corneal ulceration or superficial keratopathy</th>
<th>Intracanalicular migration</th>
<th>Partial extrusion</th>
<th>Spontaneous tubing loss or premature removal</th>
<th>Meatal ring rupture</th>
<th>Preseptal cellulitis</th>
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<td>Fayet and Bernard [34]</td>
<td>1990</td>
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None of the authors has financial interest in any of the products mentioned.

References
