19th century pioneers of intensive therapy in North America Part 2: Joseph O’Dwyer

Joseph O’Dwyer was a distinguished New York medical figure who made important advances in treatment and was greatly admired for his personal qualities, as a humanitarian and a person with nobility of character. His progress can be followed through his publications, articles about him and eulogies from his numerous admirers. He has been described as “immortalised by intubation”. Within a decade of his death he was revered by such statements as “the most godlike character I have ever seen in man” or “American medicine has no more shining light”.[p.326]

A brief biography

O’Dwyer[10-12,17] (Figure 1) was born on 12 October 1841 in Cleveland, Ohio, but spent his boyhood near London, Ontario. After 2 years under supervision, apprenticed to local medical practitioner “Dr Anderson”, he entered the College of Physicians and Surgeons in New York, graduating in 1866 at the age of 25. He then worked for 2 years as “sanitary superintendent”[10] at the New York City [Charity] Hospital on Blackwell’s Island, attracting notice by his attention to duty and efficiency.[12] O’Dwyer then transferred to a general practice in New York with Dr Warren Schoonover.[12] By 1872, 10,13 he gained appointment for the first of about 25 years on the medical staff of the Sisters of Charity New York Foundling Asylum (NYFA), where he eventually became superintendent[12][p.345] (Figure 2). The NYFA’s dependents numbered around 1800, with 600–700 indwellers and around 1200 outliers, “wetnursed or otherwise cared for outside”.[10] all were orphans or children of the poor without available medical care. O’Dwyer’s stable New York practice included attendance at ultimately over 3000 obstetrical deliveries[10] “in poor surroundings”.[11] by devoting so much of his professional life to the medical care of NYFA children, his obstetrical commitment came to be displaced by their special problems arising from diphtheria.[11]

In the last decades of the 19th century, diphtheria was unusual among infectious diseases in that it was becoming more prevalent.[15,19] O’Dwyer was appalled to see the way in which many children afflicted with diphtheria died at the NYFA, suffocated by a laryngeal pseudomembrane (ex “Gk diphthera … skin, hide” — Shorter Oxford English dictionary). His efforts in devising methods to save them from asphyxial death produced a satisfactory system of intralaryngeal intubation by the mid-1880s, and his retrospective article of 1896[8] illustrated the evolution of his intralaryngeal tubes (Figure 3).

ABSTRACT

Dr Joseph O’Dwyer’s principal distinction lies in his dedication and achievements in battling laryngeal diphtheria among children at the New York Foundling Asylum, where he was a physician from 1872. He was also active at the Presbyterian Hospital of New York and in private practice.

Some of his pioneering work anticipated methods of intensive care medicine. His achievements included:

• Introduction of a practical system of intralaryngeal intubation, including designs of tubes and a technique for inserting them, after many years of careful study and experimentation — always “without borrowed inspiration”.

• Use of his tubes in children with diphtheritic pseudomembranes in the larynx, to substantially increase their survival chances at a time when tracheotomy for this problem still had a high failure rate. The first intubated patient recovered, November 1882, only after change to prolonged wearing of a tracheotomy tube, so O’Dwyer did not date his first intubation success until 21 May 1884.

• Introduction of his tubes into the Fell method of forced respiration, with the resultant Fell–O’Dwyer apparatus supplying practical instrumentation for intermittent positive pressure ventilation.

• Demonstration that this apparatus, primarily used for saving lives after acute opiate poisoning, was also useful with some intracranial disasters, 1894.

• Provision of a system, which others then applied, enabling surgeons to overcome the great “pneumothorax problem” of intrathoracic operations, and thereby conduct safe surgery inside the chest, 1898.

• Development of an intubating method using successive short-term dilatations for treating chronic laryngeal stenosis, usually syphilitic, in adults, 1885.

Throughout his medical lifetime, O’Dwyer was held in the highest regard as an altruistic, compassionate person of “sincere simplicity and frank goodness of character”.

Intervention became successful, such that by 1894 there was a recovery rate of around 40% among 1324 affected, but diphtheria, a “blood disease,” could still cause death in other ways, despite intubation.

By 1894, some physicians alleged that introducing calomel inhalations might produce a higher success rate than intubation. Also, intubation was less needed within a decade of the advent of Emil von Behring’s antitoxin for diphtheria in 1890, available in 1894 and then gradually adopted. O’Dwyer, later described as a pioneer “in use of diphtheria serum as a remedy”, welcomed antitoxin and promoted its acceptance by using it in the correct dose.

O’Dwyer also developed successful treatment for chronic laryngeal stenosis in adults. Then, in 1891, by using his airway intubating tubes in place of either the Fell face mask or the tracheotomy tube for delivering George Fell’s “forced respiration”, O’Dwyer widened the application of intermittent positive pressure ventilation (IPPV) beyond opiate and other poisoning, to include intracerebral disasters (first reported by Northrup in 1894), then intrathoracic surgery in 1899.

The combination, generally called the Fell-O’Dwyer apparatus, came to include five sizes of interchangeable hollow heads, the appropriately sized one of which would be threaded distally onto the short intubation tube, then intrathoracic surgery in 1899.
thoughts were turning to “the possibility of a mechanical method of treating pneumonia”, for which he had made “many clinical observations” and “provided inflating apparatus” for supplementing oxygen. O’Dwyer’s wife, Catherine Begg, his greatest supporter, mothered eight children, four surviving childhood. After her death in 1888, he seemed to slowly decline into mental and physical exhaustion, then “In the first week of December [1897] thrombosis of certain cerebellar arteries took place and five weeks later death ensued from secondary meningitis”. I note references to O’Dwyer in a few documents as Joseph P O’Dwyer. On enquiry, April 2008, the College of Physicians of Philadelphia advised: “Joseph O’Dwyer, 1841–1898, the inventor of intubation, does not appear to have a middle name. There is also a Joseph Patrick O’Dwyer, 1869–1906.”

O’Dwyer and diphtheria

When O’Dwyer joined the staff of the Foundling Hospital (a term Northrup used at times), “diphtheria of the larynx” — then commonly known as “croup” — was the leading cause of infant mortality, with a death rate of 40%–50%. As yet, toxoid inoculation and even antitoxin lay further ahead. For several years, New York City had deaths from croup annually numbering 700–1000, and very poor survival after around 200 tracheotomies. When the diphtheritic airway was acutely obstructed, tracheotomy was the only available treatment to relieve asphyxial suffocation but was resorted to only in desperation. One statistic (quoted without its source identified) had the survival chances of victims with a tracheotomy, up to the age of 3–4 years, as only one in 10. Worse, from 1873 to 1880, tracheotomy performed in the NYFA’s own “croup room” for diphtheria, did not save a single child from death. At best then, in allowing “the little sufferers to die easier”, it provided in effect no more than what O’Dwyer later called “a justifiable form of euthanasia”. Yet by the mid-1880s, tracheotomy results much better than the NYFA’s awful figures were being described by others; for example, Charles Jennings claimed 17 recoveries after tracheotomy for 36 needing it. In 1879, the airway tubes that O’Dwyer was trying to modify with the aim of “increasing the expulsive powers of the cough”, were still tracheotomy tubes. Their failure drove him to find a better treatment; later, he said the “complete failure with tracheotomy extending over a period of several years [1869–1880] was the real incentive to the work”. O’Dwyer, essentially a modest man, reflected in his later years that he had been able to successfully attack the problem only by learning and developing “systematic thinking … outside the beaten track … from the beginning to the end … without borrowed inspiration”. In 1880, he decided to try an artificial orolaryngeal “channel through the larynx” by designing metal tubes, about an inch long and placed subglottally within the vestibule of the larynx, to completely tampon off the glottis. (Rudolph Matas referred to “O’Dwyer’s epoch-making observations [of an intralaryngeal tube] first published in January 1880”. He did not provide references for such a year, nor have I located any confirmatory paper. When O’Dwyer referred to 1880 in 1887, it was not about his publishing, only his “operating” and experiments. Thomas Keys followed Matas with the same “1880” for O’Dwyer’s publishing.

In 1882, William Perry Northrup (1851–1935), then 10 years graduated, joined O’Dwyer as research co-worker at his own “cold corner” of the NYFA’s autopsy room — “that lugubrious underground cell”. Until 1882–1883, O’Dwyer was unaware of the mid-19th century failure in France of proposals from Jean Antoine Eugène Bouchut (1818–1891) for intralaryngeal intubation (see Appendix 1A). O’Dwyer’s writings indicate that his own intubations, ultimately successful, came from no flash-in-the-pan “discovery”, but prolonged, systematic, repeated studies pursued over half a dozen years, combined with much practice on models and cadavers.

Failure despite intubation for laryngeal diphtheria

O’Dwyer’s interventions could be successful only when the airway obstruction to be relieved was confined principally to the larynx. However, despite intralaryngeal intubation, multiple factors could deny him success:

- death from toxaemia of diphtheria, with or without airway problems;
- pseudomembrane formation in the airways beyond the larynx (fatally, 57% at the bronchus, 37% in the bronchioles), producing untreatable asphyxia; or slough coughed up from below, and fatally blocking the airway passages or inserted tubes; and
- disasters occurring with the laryngeal tube itself — during introduction or extraction, or on accidental extubation.

Development of intralaryngeal tubes and intubation

O’Dwyer’s accounts clearly set out his struggles for clinical success over 1880–1885, with many heart-breaking failures, and are supplemented by Northrup’s lucid chronological histories of his colleague’s progress. The writings of both indicate how much time O’Dwyer spent at the autopsy room to study airways for anatomical learning and
to try out successive experimental designs and modifications, first of intralaryngeal springs, then later of tubes, long before making “live” trials. Initially, O’Dwyer’s devices rested solely within the larynx.8[p.11] He made numerous models, moulding putty into specimen larynxes, and tried multiple versions of various lengths, shapes, sizes and appendages; and, after his first successes, a whole succession of “modifications in the size and shape of the heads of the tubes” to enable swallowing for feeding.2 The number of tubes O’Dwyer must have had constructed and modified, before reaching satisfactory solutions to multiple problems, does seem amazing.

O’Dwyer started his clinical trials of intubation with a “[long] prostatic catheter introduced by the nostril”,3 but quickly discarded it, progressing to a small, simple, laryngeal “skeleton wired spring”10 soon also found unsuitable. Various designs and lengths of “laryngeal spring or speculum” followed, a small bivalved device which Northrup (O’Dwyer also) often referred to, not as a tube but still, as a (laryngeal) “spring”. Initially, the various spring designs, also their introducers, were home-made by O’Dwyer’s valued helper, the mechanically gifted house physician, R E Chadbourne,11 whose recognition seems to have been documented rather late. The ancillary equipment of introducer (especially), mouth-gag and extractor comprised essential ancillary equipment.

After 3 years of experimentation, O’Dwyer had moved on from bivalved tubes, to trying “solid” plain tubes, 1883, conducting “numerous experiments with an extensive range of successive modifications”.2 By then, he had expert instrument makers for his metallic designs which, from the beginning, represented a significant advance on Bouchut’s tubes (cylindrical and short, “a little smaller than a common thimble”29). O’Dwyer illustrated multiple changes,8[p.20] and catalogued the tube-head changes.2[p.685]

To effect intubation of a conscious child, O’Dwyer and Northrup needed to use very careful technique, described first in 1885 by O’Dwyer,1 briefly by Northrup,34 then O’Dwyer4 in 1887, and in considerable detail in 1888 by Frank Waxham,35 whose remarkable book of the same year36 had 45 engravings of technique (Figure 435). Gel- fand’s article in Caduceus17 (now defunct) has a series of historical drawings from the Dittrick Museum of Medical History, liberally illustrating O’Dwyer’s careful intubating techniques and instrumentation.

**Evolution of O’Dwyer’s intralaryngeal tube**

**The bivalved spring–tube, or speculum**

O’Dwyer’s first shaped tubes for children, 1880, were metallic, bivalved and ellipsoid front to back, with a narrow transverse diameter. The two “valves” were held together until the introducer (designed to guide insertion, being performed by finger-touch) was removed, when the valves sprang apart to grip the laryngeal walls.10 “A great deal of experiment was required to get the spring of the proper strength.”10 A loop of braided silk able “to run freely through the eyelet of the tube”34 was withdrawn only after the speculum was safely inserted (sometimes the silk was left attached, with the other end affixed around an ear35). An extractor could engage in the small slit in the tube’s side. The length of the tube was at first a maximum of only 1.5 inches (3.8 cm), then extended to 1.75–3.0 inches (4.4–7.6 cm), with a tube-top “rubber collar” or
“shoulder” of chloroform-softened gutta percha, “applied layer after layer until a sufficient thickness was obtained”. It prevented the tube from slipping further down the trachea.

After 3 years, the bivalved design was “reluctantly given up as useless” because, among its multiple flaws, O’Dwyer found swollen mucosa or pseudomembrane progressively intruded between the separated blades into the airway, again “obliterating the breathing space first obtained”, and providing “the greatest difficulty and one that proved insurmountable”. Soft tissue could also block the head’s entry site into the tube, while similar intrusion into the slit for the extractor led to it being abandoned.

Clinical applications of the speculum

From an entry in the NYFA deaths book, the first intubation with a laryngeal spring/speculum was performed on 20 October 1882 on a 4-year-old (awake) girl, relieving her asphyxia. However, later removal of the spring led to relapse of the asphyxia after 8 hours, so tracheotomy was performed; but she died the following day from asphyxia caused by pseudomembrane formation deeper into the lungs — “to finest bronchioles”.

O’Dwyer did not make much of the November 1882 first recovery of a tracheotomy patient since the Hospital’s foundation (on 11 October 1869). Yet, that was a real triumph, as every previous “operation” at the NYFA had ended in total failure. O’Dwyer did not tell us how long the bivalved tube was first in place, before protracted wearing of a “secondary” (tracheotomy) cannula for 6 months, with two laryngeal operations, eventually enabled final extubation. (As laryngeal intubations became more frequent, a policy was adopted that patients who survived initial intubation and were judged to be “the most hopeful” subsequently received a secondary tracheotomy.)

Intubations on two further patients failed to prevent their deaths. O’Dwyer performed the NYFA’s third documented insertion of one of these under chloroform anaesthesia, 26 January 1883 but within 10 minutes the child had to be extubated to allow extraction of pseudomembrane too wide for ejection through the spring’s lumen. “Apparently dead”, she was resuscitated by artificial respiration (type unspecified), then re-intubated with a larger spring, but extubated 5 hours later. Her condition immediately worsened, her mother refused to allow the tracheotomy then essential, and the child died. (At this time it was characteristic for parents not to want tracheotomy or to give consent.) Springs were then given up. Nevertheless, the self-retaining bivalved tube, once inserted, had been “always retained and gave prompt but transient relief to the dyspnoea”. Later, in 1896, O’Dwyer assessed the situation at that stage: “Tracheotomy was bad, but intubation so far was worse because it interfered so seriously with feeding”. Understandably, such situations must have been exceedingly disheartening for O’Dwyer, his team and the nursing staff.

Contrary to widespread belief or expectation, these intubations importantly did demonstrate that the human larynx would tolerate a tube, without damage; and air could enter the lungs and secretions exit. (Bouchut had previously demonstrated this, in 1858.)

Plain tubes

After 3 years of struggling with bivalve trials, O’Dwyer “concluded to try instead a solid tube of plain oval form”, at first small (“about one inch long”), again with an introducer. The new tube was “longer than the speculum, narrow, oval, or flattened laterally, having a collar [to rest on the vocal cord] at its upper end”. Insertion of the tube was aided by the leading rounded head of an obturator; and again an attached loop of braided silk thread. A tube extractor, improved in the summer of 1886, could engage in a small posterior slit on the tube’s top; and Waxham later invented a valuable laryngeal forceps.
Do “let us bear in mind that the backward curve, the blunt rounded head of such odd shape, the knobbled lower end, with the thin-walled, laterally compressed upper end (of the tube) were the results of long painstaking study and experiment, measurements and casts, trials of models, changing and changing for six years”. 10

Due credit must be given to O’Dwyer’s instrument makers. Earlier tubes were from his unnamed “little German” craftsman,10 then H Keller of New York; genuinely “O’Dwyer” sets were provided by Geo Tiemann & Co. New York,34 while Chas Truax and Co, Chicago, manufactured Waxham’s modification of O’Dwyer tubes,36 “with rubber epiglottis” — which O’Dwyer demonstrated2 (Figure 5).

Aspects of plain tubes
Retention. An important spindle-shaped “retaining-swell”, finally evolved for the midtracheal part of the tube, proved best for providing retention (see Footnote 1).

Difficulty in feeding intubated patients.2 There was much concern over ensuring adequate nutrition; eventually it was realised that despite various modifications to the tube-head “no artificial device could overcome the difficulty of swallowing … when a tube is worn in the larynx for several weeks the ability to swallow perfectly was acquired”. 8[p.16] With the tube’s head occupying the vestibule of the larynx, the epiglottis could close over it during swallowing.1 Eventually head-down feeding (or the Casselberry method of “swallowing up hill”10,21) was adopted8 (Figure 4D).

Pressure ulcerations.8[p.13] Also troublesome, these occurred especially at the base of the epiglottis and within the cricoid ring (apparently it was O’Dwyer who recognised that the cricoid had the narrowest calibre in the upper airway10). Extensive experimentation enabled progressive reduction of the calibre of the tube, so much so that “everyone marvelled” it could still allow satisfactory breathing.10

Tube properties. With diphtheritic distal obstruction found around the end of many small tubes after death, tube length was increased to within half an inch of the tracheal bifurcation — such tubes were “never expelled”.8[p.13] O’Dwyer started with (nickel-)steel tubes and obturators; the last modification was trying tubes made of “hard rubber” (vulcanite), not metal, which proved best for the material of the tube-head, concerning incrustation and corrosion; like metal, it could be boiled for disinfection.10 After the initially imperfect equipment, later models were highly refined.

Wide short tubes8p.17-8 (“Loose membrane or foreign body tubes”)21. O’Dwyer developed short, very thin, metal tracheal tubes, three to four times wider than standard tubes, for extracting or breaking up pseudomembrane. These tubes, illustrated by Northrup10[p.2] were in place for only a few hours at a time and “proved fairly successful in getting rid of false membrane when loose and not anchored below by extension into the bronchii”. 8[p.18]

Clinical applications of plain tubes
Northrup10[p.362] quotes, 25 April 1884, from the NYFA’s deaths book for the outcome of O’Dwyer’s first trial with a plain tube, supplied to an infant aged “2 months and twenty four days”, with the breathing state relieved to “fairly good”. The infant then accepted almost a pint of milk; with ease of breathing “retained until the child died sixteen hours later, free from any return of dyspnoea”8 — presumably succumbing to diphtheria toxicity. The first mention of “tube” is also made for that date in the same book.10[p.362] (Paluel Flagg, closely liaising with a medical son of O’Dwyer’s, 1909 and 1934,16[p.12] states O’Dwyer “first applied the ‘oval tube’ on 23 April 1884”8[p.9] — one would expect on 24 April.10)

O’Dwyer then dated his second patient to be relieved, a girl aged about 4 years, for 21 May 1884.8[p.12] She survived 67 hours of intubation, was extubated, but after a further 5 hours needed re-intubation — for which O’Dwyer had to administer chloroform to withdraw his (shielded) finger, leading him forthwith to construct a mouth-gag. After 7 days she coughed the tube out, to become his first survivor with one of his plain tubes. O’Dwyer later hailed this success (rather than their 1882 survivor) as “the first recovery in the history of intubation, and was, therefore, a very important event”. Only after this triumph would O’Dwyer agree to consider operating on patients outside the hospital.11 The newly coined word intubation “became associated with the operation”.10[p.362]

None of the next seven children intubated with this kind of short tube survived.8p.13 For a boy of 4 years, O’Dwyer’s third patient,1 one in whom dyspnoea returned after 24 hours followed by his death, the tube did not extend sufficiently into the trachea and its distal end “was found obstructed by a thick deposit of pseudo-membrane”.

Footnote 1. “Longer tubes reaching nearly to the bifurcation were kept in place better, but after a cough the long tube … had to be pushed back with the finger. A second shoulder was then added to the tube, below the expansion or head at its upper extremity. This shoulder kept the tube from being repelled, but the abruptness of its upper border made extraction very difficult. The abrupt shoulder then gave way to a gradually tapering enlargement … [and the tube] … when projected upward by coughing, will slip back into position by the pressure of the vocal bands on the sloping sides, aided by its weight. This retaining swell [at mid-tracheal position] is only made to hold the tubes loosely in the larynx, in order to permit of their easy expulsion in cases of sudden occlusion by masses of pseudo-membrane too large to pass through.” 34 (Bold text is my emphasis).
Use of a new tube, without a hole/niche for the extractor to engage, produced only one more survivor from five further patients, in December 1884, and that was after a boy’s 10 days of intubation amid repeated perils to the wearer.8[p.13] “Intubation was now looking up. It had two recoveries [= survivors] to its credit in five years and the prejudice against it was abating."8[p.13]

With tubes long enough “to reach clear to the [tracheal] bifurcation”, 1885, placed in six patients, all died. A further tube with a second retaining shoulder, laterally below the cords for 10 patients, produced one survivor, “the third recovery since the beginning of the experiments”.8[p.14] These tubes were never expelled from the larynx.

Multiple further design changes to deal with serious problems of feeding, ulceration sites, tracheal casts of membrane, all took further long periods of study and experimentation before O’Dwyer could publish two major series of 50 patients, 18874 and 1888,5 documented below.

**Adult plain tubes**

O’Dwyer could later state6[p.18] (incorrectly, actually; see Appendix 1B, 37-40 William Macewen) “at this time [December 1885] there was no such thing as an adult intubation tube.” But 2 years later, as per vol. iv of the Transactions of the 9th International Medical Congress, Washington, 18877[p.146] he presented an 1885, an 1886, and “other cases” of treatment of adult chronic (syphilitic) stenosis of the larynx. After much careful study and measurement, his first adult set was constructed in multiple sizes for a woman with such narrowing; but none of these tubes would penetrate the stenotic scarring, even the largest of children’s tubes was inserted only with traumatic difficulty. After her first sequence of laryngeal intubation followed by later extubation, a process repeated eight times during 18 days altogether, he increased the spells with successive indwelling tubes of progressively increasing size, enabling lengthening intervals between periodic reinsertions; such that in 1894 he could report (at Bristol in the United Kingdom, where WF Brook referred to his own five cases7[p.1482]) that by then her freedom from re-stenosis had lasted 5 years.

By June 1887, O’Dwyer had intubated another woman “over fifty times, leaving [the tube] in the larynx on several occasions as long as a week at a time”.:2 another woman wore a tube “continuously for over 10 months”. “Other cases of chronic stenosis followed in quick succession. On the experience thus derived, the set of [10?] adult tubes was constructed.”8[p.18] Tubes were originally metal, then hard rubber,2 and were used later for the Fell–O’Dwyer apparatus for IPPV and anaesthesia (to be discussed in Part 3 of this series).

**Further documented clinical applications**

**1880–1885: O’Dwyer’s experiments with intubation**

O’Dwyer reported his agonising “experimental stage of intubation”, from January 1880 to December 18854[p.557] (Despite giving his starting date as January 1880, he wrote in August 1885 that he “began experiments, almost five years ago” — that is, not before August 1880.) During this whole initial period of “developing and perfecting the tubes and accessory instruments”, O’Dwyer reported “operating on” 65 “desperate” hospital patients, 60 of them in the NYFA, of whom only nine (<14%) survived. Some “without any marked cyanosis” died with “evidence of toxaemia … for some time”.4 (O’Dwyer also reveals records missing: “there is a break … extending from August 1883, to April, 1884, which I cannot account for”.8[p.12])

After O’Dwyer’s “third patient” with a plain-tube insertion, referred to above, he admitted feeling obliged to present, then to publish (August 1885), his design of plain intubating cannulas, despite not wishing to do so without “a greater degree of perfection” — as, with only one of three child patients surviving, and that notable success an only one after inventing “tube after tube”,41[p.158] he assessed his work as still of “a purely experimental character”. Mushin and Rendell-Baker declared41[p.158] O’Dwyer’s work as “not recorded until a history of the Foundling Hospital was written in 1884”. (Waxham later summarised his own parallel progress during 188542 — Footnote 2.)

**1885–1886: O’Dwyer’s first 50 intubations in private practice**

Between 5 December 1885 and 6 December 1886, O’Dwyer performed 50 intubations in private practice.4 Survivors totalled 12 (24%), with their tubes averaging 5.3 days in situ. O’Dwyer supplied some specific case details, with the cause of death in 18 of the 38 considered an untreatable “extension of the membrane to the bronchi” — although no autopsies were performed. O’Dwyer’s excellent, explicit paper clearly defines the skill needed for
attempting intubation, and seven dangers he identified with that procedure; his own expertise becomes most evident. He emphasised that in his practice he had “never resorted to intubation until the symptoms of laryngeal obstruction were so urgent as to plainly indicate impending suffocation, unless the child were relieved by operation”. For four dyspnoeic others he was called to, he held off “operating” – and they survived.

Northrup analysed NYFA autopsies after laryngeal diphtheria, reporting 11 December 1886, 87 recorded deaths of which “In 56 the diphtheria began in the larynx”. By the next June, he reported there were 20 more deaths, all from laryngeal diphtheria.43[p.686]

1886–1887: O’Dwyer’s next 50 intubations in private practice

O’Dwyer reported his next 50 intubations in private patients, between 16 November (presumably a typographic error for December) 1886 and 18 November 1887. These patients were “operated on”, usually in consultation, with three occasions when O’Dwyer alone performed the intubation. Tubes were maintained in situ for 12 hours to 4 days; the first 15 patients died (how daunting!), but 15 survived, a 30% success rate. O’Dwyer details two severe cases for whom he considered he could withhold intubation, who recovered after “an emetic of turpeth mineral” with “bichloride of mercury” (see Footnote 3A); for one, steam vapour also. He considered Hg₂Cl₂ contributed in part to eight of 15 autumn patients recovering, and that its early use might obviate the need for intubation (see Footnote 3B).

O’Dwyer presents clinical details of seven severely ill; of several accidents; and details the third of three instances of complete obstruction of the tube by a large tracheal cast, causing sudden apnoeic death. Two “out of 173 cases so far” had their coughed-out tube enter their stomach.

This “analysis” paper describes a Heimlich-type innovative manoeuvre for expelling intralaryngotracheal material, when a tube prevents glottic closure.5

1885–1889: reports to the Academy of Medicine of New York

O’Dwyer and Northrup were frequent contributors to meetings of the Academy of Medicine of New York, with documentation (including discussions) in New York’s Medical Record and Medical Journal. O’Dwyer’s expertise, and especially the intubation versus tracheotomy dilemma, attracted widespread interest, with commentators from as far as California.

1894: Northrup, O’Dwyer and the British Medical Association

In July 1894, after almost a decade of treatment, Northrup and O’Dwyer presented their methods at the 62nd Annual Meeting of the British Medical Association in Bristol, UK. They spoke to the “Sections of Laryngology and Otology and Diseases of Children”, Northrup on acute laryngeal obstruction and O’Dwyer on chronic. Northrup reported the risk of inadvertently pushing down diphtheritic membrane during intubation and mentioned three occurrences during O’Dwyer’s first 209 cases. (There he also announced first use of the Fell–O’Dwyer apparatus,23 to be discussed in Part 3.)

1896: O’Dwyer’s address to the American Pediatric Society

On 25 May 1896, 2 years before his death, O’Dwyer provided a detailed retrospective on his entire “evolution of intubation” in his presidential address to the 8th Annual Meeting of the American Pediatric Society. Although others previously had intubated the larynx on sporadic occasions (well described by William Macewen30i), O’Dwyer was the first to systematically develop a method he then used successfully on enough patients to establish its validity in saving lives.

Problems associated with intubation and tubes

O’Dwyer needed to perfect a “blind” technique for intralaryngeal intubation of a conscious, terrified child, then ensure the tube’s maintenance in situ, usually needed for days. But other problems needed attention: determining optimal design for tubes and obtaining the best material for fabricating “tubage”; also those difficulties so well known in intensive care practice — keeping the tube’s lumen patent; sealing off the airway below the cords to enable feeding without aspiration; foiling self-extubation, and ensuring retention of the tube, while still enabling its ready

Footnote 3. The alternative use of calomel for croup.

A. Nomenclature: O’Dwyer always describes “bichloride of mercury”; Northrup writes “calomel” which is mercurous chloride, Hg₂Cl₂. Note, however, mercuric chloride, or [true] bichloride of mercury, HgCl₂ is “corrosive sublimate”.

B. Calomel inhalations: (administered from a fumigating lamp in a closed “crib tent”). I felt ambivalent whether sufficient evidence was provided for real worth in laryngeal diphtheria. Its use was “first publicly advocated by Dr. JC Corbin, of Brooklyn, in 1881, was later taken up by Dr O’Dwyer in New York, and has steadily gained in favour”. Northrup told the British Medical Association in 1894 it allowed “better and speedier recovery” when used after “operative procedure”, and quoted successful use in hundreds of patients; but he still cautioned that “Statistics have not accumulated sufficiently to frame a strong argument”. Later, 1904, Northrup was citing calomel for “promising early results for croup-laryngeal diphtheria. It was thought to reduce the mortality from 75 to 40 per cent”.

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removal; providing humidification; plus that feature specific to diphtheria — coping with obstructive membranes coughed into the tube from the trachea and beyond.

O’Dwyer’s personal problems and difficulties
Craig Gelfand’s generously illustrated, fine account describing the many battles O’Dwyer faced is an interesting read, as are Northrup’s two valedictions. O’Dwyer’s studies persisted with dogged tenacity despite disharmonising clinical failures and heavy criticisms. Even when he could invoke his first few successes, he still found initial refusal to accept his new method of treatment; or worse, opposition, not only from many colleagues but also among some NYFA staff (but from Sister Rosalie, and the “famed superior”, Sister Irene, came only support). It seemed to many that the insertion of his tubes was torturing children already suffering severely from their asphyxial disease and fearful of intubation. Some children were taken from the hospital to insalubrious homes to avoid it, and some “out-children were not returned to the hospital for treatment.”

Further difficulties arose from strong professional scepticism or antagonism. Initially, experienced US tracheotomists, such as Dr Charles Jennings (who emphasised the “personal equation” factor) and Dr Max Stern, could present, with moderation, arguments for and against intubation, while seeing tracheotomy as equally or more effective. But Waxham, strongly advocating O’Dwyer’s methods, modified O’Dwyer’s tubes and reported his version saving 269 lives after 1000 intubations. O’Dwyer’s drive for intubating came from the absolute failure of tracheotomy at the NYFA, yet others were much more successful (Footnote 4). Controversy also ensued in Australia (see Appendix 2) brought all the problems he had spent a decade struggling to circumvent. In the absence of a patent on O’Dwyer’s tubes, Northrup was appalled to find (as Jeffreys Wood confirmed) that — at O’Dwyer’s request — he could simply pick up “in London and different places samples of tubes that their best makers were selling, and tubes made from models sent out from New York with O’Dwyer’s approval. They were a travesty. They embodied every vice.” Some doctors would rush to buy an instrument set and try to insert a tube without any of the training on cadavers needed to become experienced, “They had all manner of accidents”. O’Dwyer had warned in 1887 that “Intubation is apparently, but not really, a simple operation”. (In 1887 and again 1896, Northrup appeared to discount — certainly failed to confirm — this.)

Patients outside the NYFA could be sent there for O’Dwyer’s personal management. But when an intubated child died by asphyxia from extension of the diphtheritic pseudomembrane peripherally into the bronchi and beyond, plenty of opponents were ready to blame the death on the tube or O’Dwyer himself. The inexperienced had deaths during rough intubations, and also with extracting tubes; tubes could become obstructed. Accidents could happen with the tubes as may occur today. Nurses mindng children’s tubes became skilled, but they were not today’s trained intensive care nurses. (One argument advanced for intubation over tracheotomy was that the former was more readily managed in a poor household! Thus, from Max Stern, 1887: “intubate poor patients when they cannot get good nursing [for a tracheotomy],”)

O’Dwyer’s temperament made all setbacks personally devastating and debilitating, yet Gelfand considers him displaying “a resilience and strength uncommon to most”.

Declining need for intubation
Ironically, O’Dwyer’s widest recognition, medical and lay, was eclipsed when the need for his tubes in diphtheria decreased or was even eliminated with improvements in the antitoxin. Diphtheria antitoxin, announced in Berlin, 1890, by Emil von Behring (1854–1917, medicine’s first Nobel Prize winner, 1901) and Shibasaburo Kitasato, was taken up enthusiastically by O’Dwyer himself, once it became available (from horses). Pierre-Paul Émile Roux of Paris also developed effective diphtheria antitoxin independently and modified treatment, 1894. The antitoxin concentration in the first available doses was too low, at 50–100 antitoxin units, when 2000–3000 units were needed, causing many to repudiate it; but O’Dwyer persisted. Antitoxin came to reduce the need for his tubes, even more so after Roux’s
nephew Gaston effected conversion of diphtheria toxin to toxoid, enabling development of immunising vaccine, followed by successful trials, 1924.18p.71

Waxham could document2 the recoveries in his successive series of 100 intubated patients at 27, 34, 40, 38, 39 (so 178 of 500, or 35.6%); but then, with antitoxin additionally, mortality for the next 70 was four (or 6%). Distinguished “virtual founder”53,54 of American paediatrics, Abraham Jacobi (1830–1913) — O’Dwyer’s zealous convert to intubation — found that antitoxin use dropped the need for “operation” (presumably intubation) in laryngeal diphtheria from 90% to less than 40%.20p.548

Recognition for O’Dwyer

Eventually, O’Dwyer came to receive full recognition and honour, initiated by Abraham Jacobi at the (New York) “State Medical Society, February, 1887”, 10Footnote,p.363 and then wider afield within the US, much of continental Europe, the UK (slowly there, much “due to the faulty construction of the instruments that are made in England, after the pattern of O’Dwyer’s earlier tubes”49p.177), and Australia. The ovation O’Dwyer received at the IXth International Medical Congress, Washington, September 1887 (in such contrast to Fell’s reception there49) was for his efforts in developing his intubation system.18 By 1894, at a Nuremberg research conference, his intubating method could be credited with a recovery rate of around 40% for 1324 diphtheria patients.18 Two years later, he was President of the American Pediatric Society.8

Reports of intubation used in diphtheria by other American clinicians were soon documented in later-1880s issues of New York medical journals. O’Dwyer’s influence continued into the 20th century, influencing intralaryngeal tubes for diphtheria, as documented,11,20 and awareness seemed continued undaunted, despite years of failure and criticism, in diphtheria was documented in Melbourne in the mid-1920s51 (Appendix 2).

For surgical anaesthesia, others used O’Dwyer’s design of a longer tube developed for IPPV,6 as will be discussed in Part 3. Eventually, during the 1920s, Ivan Magill (1888–1986) and Stanley Rowbotham (1890–1979) gradually developed a single-lumen, wide-bore, endotracheal tube for bidirectional gas flow, and it became the dominant form for anaesthesia.56 The same principle of a wide-bore tube had been introduced in Germany two decades earlier by Franz Kuhn (1866–1929), but this was largely overlooked.56 Although O’Dwyer, supported by Northrup, was hailed for introducing his tubes into the intensive therapy of severe airway disease (“croup and kindred diseases”), he was also a pioneer in providing a means for the efficient application of Fell’s “forced respiration” principle in rescue IPPV23,52 In the US, others adapted this for anaesthetic IPPV.26 The Fell–O’Dwyer apparatus offered a workable solution for the great pneumothorax problem of thoracic surgery,24 as will be discussed in Part 3.

Priority rights for intubation: Bouchut, Macewen or O’Dwyer?

In science the credit goes to the man who convinces the world, not to the man to whom the idea first occurs.

Francis Darwin, Eugenics Review, 1914.57

After the mid-19th century, these three pioneers each tackled the problem of diphtheritic acute stenosis of the larynx by “blindly” using a finger technique to insert a tube into the larynx, perhaps trachea also. So the device O’Dwyer employed for his solution had been anticipated by two previous investigators28,29,30,40 (see Appendix 1). Although Eugène Bouchut demonstrated, 1858, that a child’s larynx could tolerate a metal tube for at least 2 days without damage to relieve acute laryngeal obstruction,29 he faced stern opposition,29,31,33 and, having lost his credibility, did not persist sufficiently to have his method accepted. And although Sir William Macewen at Glasgow successfully intubated the larynx for membranous croup in the 1870s,37,40 he did not publicise this achievement widely, or take steps to ensure its continuing uptake. He did intubate the adult larynx afterwards, using a skilled blind technique, but after three successes did not proceed further.30,38,39

O’Dwyer, often acclaimed with phrases such as “immoralised by intubation”, and one whose intubation success was considered his “undisputed monument”, has priority rights in terms of Francis Darwin’s yardstick — he firmly popularised the method. Unlike Bouchut and Macewen, he continued undaunted, despite years of failure and criticism, until his method became established. Fine commercial sets of O’Dwyer and O’Dwyer-type tubes were used worldwide
mid-European treatments, by practitioners such as Friedrich Trendelenburg, Leopold Schröter and his pupil Wilhelm Hack, of chronic stenosis of the larynx, usually syphilitic and in adults, by dilatation with tubes. Following soon thereafter, it was again O’Dwyer who effectively publicised his successful method of such treatment.

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Appendix 1. Further on the priority rights for intralaryngeal intubation

A. Jean Antoine Eugène Bouchut (1818–1891)

In Paris on 14 September 1858, the young paediatrician Eugène Bouchut, “prof.-agréé”, addressed the Academy of Medicine on his trials conducted with “a silver, truncated, hollow cone, a little smaller than a common thimble” (18–24 mm long; 6–15 mm wide), with an introducer he placed it, “on the point of a hollow sound” into the larynx, first in a cadaver, then for two children “affected with diphtherite”. At the upper part of this tube there were a pair of rings, between which the vocal cords were supposed to rest and hold it in place (a tube is illustrated in Gelfand). An attached silk thread “hangs out of the mouth”. The tube dilated the airway, “to the great relief of the child” from “paroxysms of suffocation”. After successful intubations in two diphtheritic children, one for 36 hours, the other for 42 hours, the cones were “subsequently removed with the greatest ease”. The first child (although “elle était guérie du croup”) did not survive the toxaemia and pneumonia. The Lancet of 2 October 1858, while regarding her death as a failure of Bouchut’s method (if “cured”, then surely they did so unfairly?), did accept he had “proved” his laryngeal cone could be tolerated and could relieve the “suffocation of diphtherite” (see Footnote 5).

Bouchut advised his colleagues that adopting his cone for intubation in (acute) “laryngeal stenosis” would avoid tracheotomy; but they wanted a committee to investigate his claim first. After 2 weeks of consideration, the commission, with the renowned tracheotomy exponent Armand Trousseau (1801–1867) as secretary, reported that, despite intubation having some virtues, tracheotomy was decidedly the “principal” option of choice. With Bouchut’s initiative “quickly suppressed by the French Academy of Medicine at the instigation of Trousseau”, the older operation [tracheotomy] continued to dominate in France.

Footnote 5. Nearly 30 years on, in New York’s Medical Record of 15 January 1887, an (anonymous) annotation on the early history of intubation of the larynx referred to the investigating committee’s report as delivered in Paris 2 weeks after September 14 1855 — a year Gelfand also quoted, which surely must be a typographic error for 1858, the year of Bouchut’s publication — other writers concur for 1858. The Rapport of the investigating committee’s decision, released in Paris at the end of September 1858, obviously reached London for publication in the 2 October Lancet (Paris and London had a telegraph link from 1852).
Appendix 1 continued

B. Sir William Macewen (1848–1924)37

William Macewen, famous surgeon and neurosurgeon, is renowned for the four experiences in Glasgow he labelled Cases I to IV (the first three in 1878, the fourth before July 1880, and all thereby before O’Dwyer’s interventions), when he used orotracheal intubation for adults. For the first, Case I,30,38 he also packed off the pharynx for major orolinguopharyngeal surgery: “to occlude Haemorrhage from Larynx, and for administration of Anaesthetic”, with postoperative extubation “when the haemorrhage had ceased and the patient regained consciousness”.30[p.122] He repeated this intubation similarly to successfully treat two other acutely obstructed airways, 30,38,39 after which Macewen recorded no further intubating attempts. (Case II30,38 of a man’s glottis burnt from a hot potato; tube in situ 36 hours with three intromissions, removed after 39 hours total; Case III30 of “acute oedema glottidis following chronic laryngeal affection”; tube in situ 30 of 35 hours total time, with temporary removals 12-hourly.30[p.123] Case IV: of a further surgical candidate who had agreed to tube anaesthesia but removed the pre-inserted tube before tube anaesthesia could start; then about 15 minutes after the house surgeon started a chloroform inhalation, died suddenly30[p.163].

Macewen’s British Medical Journal documentation of each event is very detailed (those in the Glasgow Medical Journal38,39 are brief). He also gave careful reference to Bouchut’s and others’ earlier efforts, and cited two patients “observed” receiving P-J Desault’s [1790s] nasotracheal intubations, with one survivor (Macewen regretted that learning opportunities for others did not follow on). He also cited Dr Wilhelm Hack’s patient at Freiburg, November 1878, relieved after an hour’s self-intubation for acute on chronic “oedema glottidis”.30[p.164]

Neither Macewen’s two papers reported to the Glasgow Pathological and Clinical Society in 1879, nor his two fine 1880 British Medical Journal articles, mention diphtheria patients, but Dr CT James37 informs us as follows: first, it was earlier, when Macewen was Medical Superintendent of Glasgow’s Belvidere Fever Hospital and “faced with diphtheritic obstruction of the glottis”, that he “most probably formulated his ideas about laryngeal intubation as an alternative to tracheotomy”; and that 1870 was the year “when he was most active in this field” of experimental work (preceding O’Dwyer even further). Through the title William Macewen, renowned surgeon who, early in his career, 1870s, intubated the larynx for diphtheritic “croup”. (With thanks to the Wellcome Library, London, for their courtesy.)

The surgical treatment of croup and diphtheria by the introduction of tubes into the trachea through the mouth, with which the British Medical Journal very briefly reported on Macewen’s paper to the International Medical Congress in London in 1881, there should be no doubt of his intubating earlier for diphtheritic laryngitis. Unfortunately, however, as case numbers are not supplied (as James says, “The number of [Macewen’s] cases of diphtheria which were treated by intubation instead of tracheotomy is not known”); worse, ambiguous interpretation is possible (see Footnote 6) — even that Macewen had performed the procedure only once for membranous croup. So, although Macewen’s 1881 London presentation may indicate he used intubation for that disorder in Glasgow, thereby also anticipating O’Dwyer,37[p.746] more detailed evidence would be welcome. And while Macewen does not appear to have persisted with treating infectious disease problems during his illustrious surgical career, neither does it seem his intubation writings30 refer back to his using intubation for croup. James’s article37 illustrates Macewen’s various tubes.

Footnote 6. Consider: “Dr Macewen related several cases in which he had introduced flexible [metallic, articulated] tubes into the trachea through the mouth, and gave details of one case of membranous croup in which their use had been attended by marked success. He showed a flexible silver tube, and some gum-elastic tubes; the latter he found the more satisfactory. Dr Robertson [of Glasgow] had seen some of Dr. Macewen’s cases, and … had seen the fourth case and he found that the breathing took place freely through the tube.”.40 Was this fourth case Macewen’s only one of croup, or was it the fourth case of all those he presented at London?40
Appendix 2. O’Dwyer tubes in Australasia

W Hacon in New Zealand, 1889, in his enthusiastic evaluation of a single laryngeal intubation for diphtheria, seemed unaware of O’Dwyer tubes. Yet contemporaneously in Australia, the first publication of O’Dwyer-type intubation in diphtheria could be that from September 1890, featuring a “Dr Hales” with 38% success after 100 intubations — which Charles Clubbe deemed “a bad record”! In the same publication, Lennox Browne claimed “many successful cases”, and B J Newmarch detailed his single case.

Controversy over treatment of diphtheritic obstruction continued between two surgeons — intubation protagonist Jefferis Turner at Brisbane Children’s Hospital, and Charles Clubbe at the Hospital for Sick Children (later the Royal Alexandra Hospital for Children), Sydney, favouring tracheotomy. At Sydney’s 1892 Intercolonial Medical Congress of Australasia, Clubbe presented recovery for 42.5% of 120 diphtheritic children needing tracheotomy; and Turner, his seven recoveries among 19 intubated patients (but his last seven died). Michael Cooper (historian, Australian and New Zealand College of Anaesthetists) wrote to me: “Turner is supposed to have used the O’Dwyer tubes but does not actually mention it in his article” — then, neither does Clubbe name his tracheotomy tube — although, in Turner’s report, I note six possible indicators that he used O’Dwyer tubes.

Cooper opined: “There was quite a difference of opinion (and therefore practice) between the different states in Australia”. Some authors presented balanced viewpoints: “Intubation can always be followed by tracheotomy, if advisable”. “Tracheotomy and intubation should never be looked on as rivals, they are both very valuable operations” (tracheotomy could provide valuable access for bronchial toileting). Wood provides a thoughtful analysis.

Rod Westhorpe cites F V G (Frank) Scholes at the Fairfield Hospital, Melbourne, reporting a series of patients with laryngeal diphtheritic obstruction still being treated there in the 1920s with O’Dwyer tubes.

At the time of the book’s second edition in 1927, a series totalling 1127 patients had 16.3% non-survivors, compared with 58.7% deaths after 92 tracheotomies for the same condition. Scholes was taught the use of O’Dwyer tubes by Jefferis Turner, who was taught by O’Dwyer himself.