

19th century pioneering of intensive therapy in North America

Part 3: the Fell–O’Dwyer apparatus and William P Northrup

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Too much credit cannot be given Dr Northrup for his persistent advocacy of this valuable apparatus, the invention of his lamented and ingenious colleague, O’Dwyer.

Rudolph Matas^{1(p.97)}

At the American Pediatric Society’s 1891 meeting in Washington, DC, 23 September, Joseph O’Dwyer (1841–1898) reported^{2(p.33-4)} that, for medical patients with various respiratory difficulties, he had made *“some experiments six or seven years ago at the New York Foundling Asylum [NYFA], using the laryngeal tube ... through which air was forced into the lungs by means of a rubber bag”*. Later, in 1944, Paluel Flagg (1886–1970) confirmed^{3(p.121)} that this application *“had been in use in the New York Foundling Hospital for six years, for some of the time when it was still in the experimental stage”*. The years that O’Dwyer gave for supplying intermittent positive pressure ventilation (IPPV) in this way, endorsed by Flagg,^{3(p.11-12)} would chronologically precede George Fell’s 1887 introduction of his Fell method for “forced respiration” (equivalent to IPPV).⁴

After his own early experiments with forced respiration, O’Dwyer was impressed by the results Professor Horatio Wood obtained in his animal laboratory from using the Fell method,^{2(p.32-3)} as Wood had presented them to the 1890 International Medical Congress in Berlin. Wood considered them “remarkable”, in contrast to the “inefficiency” of resuscitation by “the Sylvester [sic] and similar methods”. By applying Fell’s method, Wood had reversed asystole and

ABSTRACT

Two previous articles in this series have described the re-introduction of forced respiration for ventilatory difficulties, particularly in opiate poisoning (by George Fell), and successful use of intralaryngeal tubes designed for treating airway obstruction in diphtheritic acute laryngitis (by Joseph O’Dwyer). In 1891, O’Dwyer extended the applications of Fell’s system, introducing a longer orolaryngeal tube, replacing Fell’s methods of inflating the lungs, which had been with a somewhat unsatisfactory facemask or through a tracheotomy tube. The combined system became known as the “Fell–O’Dwyer apparatus”. Use of the apparatus widened, to include treating apnoea from intracranial disasters (by William P Northrup, especially) and, on the initiative of Rudolph Matas, in delivering anaesthesia and maintaining lung inflation to enable intrathoracic surgery (by FW Parham). Although the apparatus was used beyond New York (eg, in New Orleans by JD Bloom, especially for neonatal apnoea), it is difficult to find other than non-specific references. Matas and Bloom improved O’Dwyer’s original system, but after the clinical success of Charles Elsberg’s continuous insufflation anaesthesia for thoracic surgery, 1909, American anaesthetists came to prefer that.

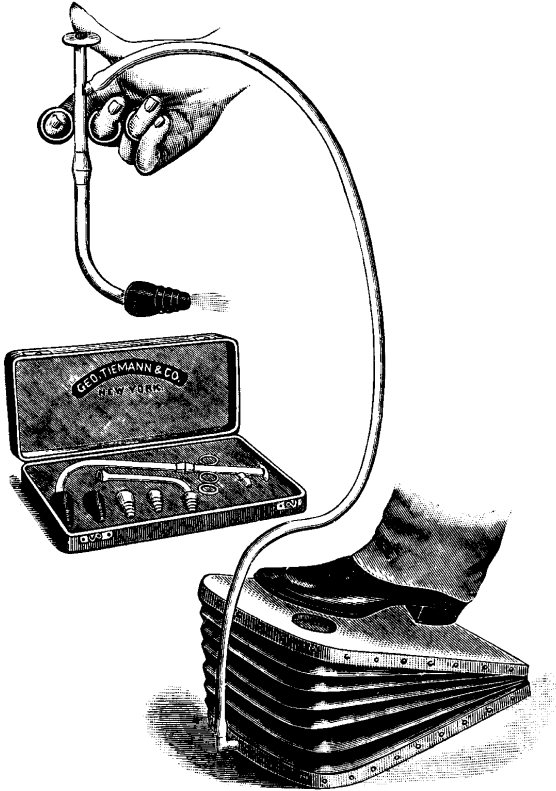
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Footnote 1. As referred to in Part 1 of this series,^{6(p.385)} O’Dwyer’s paper prompted an onslaught from George Fell;⁷ perhaps the title’s wording of “improved,” to precede “method of artificial forcible respiration”, fired up Fell, who it seems saw this as a criticism, or, worse, O’Dwyer taking over his apparatus. What particularly seemed to annoy Fell was O’Dwyer’s misunderstanding that “Dr Fell’s Method ... is identical with that practiced in the laboratories on lower animals”.⁷ Fell issued a comprehensive nine-point rebuttal of O’Dwyer’s errors over the Fell system, emphasising that his own current system, improved for humans nearly 4 years earlier, was much superior to his initial animal apparatus which O’Dwyer had assumed Fell was still using. After 18 years, Fell was speaking more kindly of “Dr John [sic] O’Dwyer whose memory we revere”.⁸ (The courteous O’Dwyer appears never to have spoken of an “O’Dwyer–Fell” apparatus.)

Re nomenclature: On many occasions, I have seen the term “Fell–O’Dwyer apparatus” referring solely to an O’Dwyer intraglottic tube, whereas the true Fell–O’Dwyer apparatus = an O’Dwyer tube + connecting rubber tubing + Fell inflating bellows.

“apparent death” from 2 minutes of apnoea after ether or chloroform (*“the heart had therefore ceased to beat”*^{2(p.33)}). O’Dwyer designed a set of intralaryngeal tubes (dated by Rod Calverley^{5(p.335)} as first in 1888) to replace the Fell system’s tracheotomy tube or face mask; and, as above, he introduced the prototype of what later came to be called the Fell–O’Dwyer apparatus to paediatricians in Washington, 1891. He first documented his improvements the following January, without illustrations² (Footnote 1) — the first depiction of the apparatus seems to have been in an 1895 paper⁹ by James Voorhees, house physician at the Presbyterian Hospital in the City of New York (Figure 1). It shows a (now longer) intralaryngeal tube with a distal tip (head), which O’Dwyer had described as “conical in shape ... to tampon the larynx below the vocal cords, so that no air can return beside it”^{2(p.31)} — ie, a seal was obtained without an inflatable cuff. (Fell had secured — and sealed

Figure 1. An “early model” of the Fell–O’Dwyer apparatus



The system comprises i) inflating bellows, ii) tubing for delivering inflating air or gases to iii) the entry one of the two ports on iv) the metal intralaryngeal cannula (showing a conical, laterally grooved, detachable head to wedge in the glottis for an air-tight fit during inspiration), and v) the exit port for the operator’s thumb-tip control of inspiratory–expiratory cycling. A Tiemann’s commercial box of tubes and heads is also shown. (With acknowledgement and thanks to the Presbyterian Hospital, New York, for this figure from their Medical and surgical reports for 1896.)

Figure 2. Cannula, tubes and heads for the Fell–O’Dwyer apparatus



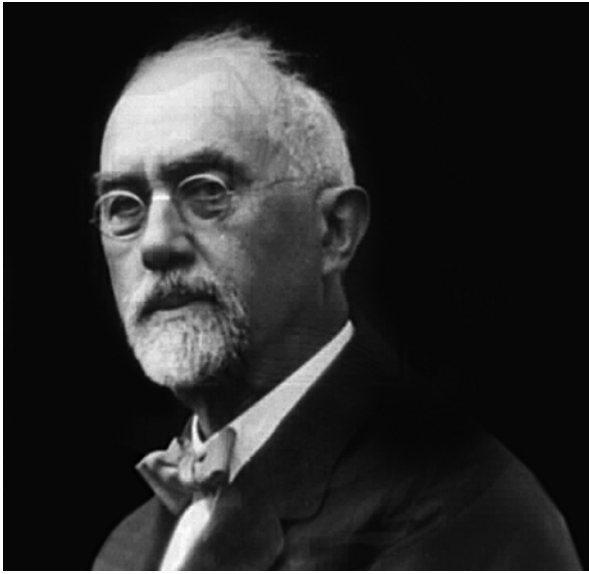
A commercial set for the apparatus of two O’Dwyer tubes (one adult and one paediatric) and five exchangeable heads. (Image courtesy of Wellcome Images, Biomedical Collection, Wellcome Library of Medical History, London, with thanks.)

off — his tube in the trachea, either by “annular corrugations or a rubber tampon”.^{4[p.155]}

O’Dwyer did not personally report further clinical use of IPPV, apart from a single instance: “During the past winter, [hence, either late 1890 or early 1891?] I tried the same instrument in one case [a patient apnoeic but conscious] with the bellows attached ... for several hours”, as apparently the patient “lost the power to breathe for himself”.^{2[p.34]} O’Dwyer advocated his apparatus for medical ventilatory needs: “inspiratory muscles ... rendered temporarily as useless, ... puerperal and other forms [of] eclampsia, and also in acute pulmonary obstruction from various causes”. (It had been for the latter that O’Dwyer made his NYFA experiments, 6–7 years earlier.^{2[p.33-4]}) And he quoted Fell’s repeated demonstration of forced respiration “in a number of cases of opium poisoning successfully treated”.^{2[p.32]} O’Dwyer also recommended his tubes designed for the apparatus as useful for airway control in certain surgical operations (so originally, the new tubes were not, as Rudolph Matas [1860–1957] said,^{10[p.1471]} only for non-surgical conditions): “to prevent blood from entering the lower air-passages during operations in or about the mouth”.^{2[p.34]} William Northrup later reiterated this.¹¹ (Note that William Macewen had also designed and used orolaryngeal tubes for that purpose, 1878.^{12,13[p.167],14}) O’Dwyer’s tubes were sufficiently wide-bore to be “at the same time, affording a free passage for the air to and from the lungs”^{2[p.34]} (Footnote 2). O’Dwyer himself did not document either delivery of an anaesthetic by his improved system, or IPPV under surgical anaesthesia by that system. However, Keyes notes that within 2 years of the description of the Fell–O’Dwyer apparatus, Karel Maydl in Prague had connected a Trendelenburg funnel to an O’Dwyer tube to modify it for “satisfactory” ororhinolaryngeal anaesthesia.^{14[p.65]} Also, by 1896, Northrup noted that “An anaes-

Footnote 2. For the definitive Fell–O’Dwyer apparatus,^{2,9,15} O’Dwyer’s metallic, oral intubating attachment had several sizes of detachable conical tips. Figure 2 shows an adult commercial set of three nickel-plated steel tube heads and two vulcanite heads, and the tubes they were mounted onto. The laryngeal end was “curved on a right angle, tipped with a conical head [laterally grooved “to allow the vocal cords to aid in holding them down”^{2[p.32]}] and designed to be of the right size to wedge itself into the larynx and prevent air from returning between it and the laryngeal wall”.¹⁵ The conical tip was graduated, so that each of O’Dwyer’s set of five heads would fit several variations of the larynx in size.^{16[p.19]} The conical shape of the head allowed the tube to wedge between the cords into the larynx, thereby sealing off the respiratory tract, enabling IPPV and preventing entry of blood, vomitus, etc, into the lungs.²

Two long tubes (one adult size, one paediatric)² featured two ports proximally: one for entry of the inflating gas from a Fell system of bellows and rubber delivery tube; the other to be stopped intermittently by the thumb, which the operator could remove rhythmically, “to act as a valve”¹⁶ allowing intermittent exit of expired air. (Fell always emphasised the need to allow sufficient time for expiration.)

Figure 3. William Perry Northrup (1851–1935)

Northrup was a strong promoter of the Fell–O’Dwyer apparatus. (With acknowledgement and thanks to the National Library of Medicine, Bethesda, Md, for this photograph.)

thetic may be administered through the intubation tube”.^{11[p.136]}

By the time of his 1896 retrospective,¹⁶ O’Dwyer was advocating the Fell bellows as the “*only one means of producing efficient and at the same time prolonged artificial respiration*” with the apparatus.^{16[p.18]} Surprisingly (and disappointingly), both Northrup’s memorial address after O’Dwyer’s death¹⁷ and his 1904 address to graduates on O’Dwyer,¹⁸ together with — nearer our own time — C Gelfand in 1987¹⁹ and HR Wiedemann in 1992,²⁰ while concentrating on O’Dwyer’s struggles to establish satisfactory intralaryngeal intubation, do not appear to find room to mention the innovative Fell–O’Dwyer apparatus, or its application during anaesthesia and that it was harm-free when used for 24 hours¹⁵ of IPPV. (Understandably, paediatric papers about O’Dwyer concentrate on treatment for diphtheria.)

The Presbyterian Hospital of New York “*was the first to own and make use of the apparatus*”.¹¹ O’Dwyer’s colleague and admirer, William Perry Northrup²¹ (Figure 3 and Footnote 3), reported in 1894¹⁵ on the first clinical use of the apparatus for one patient at that hospital, adding “*This apparatus has been brought into play several times at the Presbyterian Hospital and at the Foundling Asylum*”. It “*obviated the necessity of tracheotomy and removed the embarrassments of relaxed tongue and larynx*”.^{11[p.128]} O’Dwyer, 1892,² simply refers to the Fell–O’Dwyer apparatus being at the NYFA, without providing details. Voorhees,

1895,⁹ while mentioning use of the apparatus for neurosurgical-type apnoea, documented two patients with severe morphine poisoning who survived through the use of the Fell–O’Dwyer apparatus.

Northrup reported these three patients, and five additional Presbyterian Hospital patients, in an 1896 case series,¹¹ as described later.

Historical context of the introduction of the Fell–O’Dwyer apparatus

During the last decade of the 19th century the oft-quoted admonition from Johannes Friedrich Dieffenbach (1792–1847) that the surgeon “*should halt at the pleura*”,^{10[p.137]} “*was religiously observed until comparatively recent years by the vast majority of surgeons when attempting the extirpation of tumors of the thoracic parietes*”.^{22[p.411]} But “*Thoracic surgery was on the eve of a revolutionary innovation*”.^{10[p.1469]} Matas^{1,10,22} noted much experimental work carried out, especially during the 1890s, principally by European surgeons (many were French), on direct, intralaryngeal inflation of the lungs using positive pressure (alternatively to that use by the 1891 Fell–O’Dwyer apparatus). He saw that such a manoeuvre could resolve the great “*pneumothorax problem*”, which was otherwise inevitable when surgeons opened the chest; and it “*would appear the same thought had occurred to those surgeons [listed by Matas,^{1,10} see Footnote 4] independently of each other and about the same time*”.^{22[p.431]}

When Northrup first described a clinical use of the Fell–O’Dwyer apparatus at Bristol, 1894,¹⁵ his further anticipation was that, while “*In [peri-oral] surgery it is expected of course that the patient is capable of automatic [= spontaneous] respiration*”, the Fell–O’Dwyer apparatus delivering an anaesthetic was also airway protective. But Matas, in reading the 1896 report from New York’s Presbyterian Hospital on use of the apparatus,¹¹ realised that it would enable intrathoracic surgery to proceed safely and effectively. Because of the inadequacies^{5[p.336];25[p.13]} of

Footnote 3. Paediatrician, physician and pathologist William Perry Northrup (1851–1935)²⁷ was born near Syracuse, New York, graduated in 1868 from the College of Physicians and Surgeons, practised in New York City, then became a pathologist at the New York Foundling Asylum where he came under the influence of Joseph O’Dwyer, later becoming an attending physician at the Presbyterian Hospital. He also features prominently in Part 2 of this trilogy.¹³ An obituary notice²¹ regrets that his “*important work concerning the value of fresh air ... has been little heeded by the bulk of the profession*”. He was summarised as “*a man of general culture [twice, a teacher of Greek], a good physician, a wonderfully attractive lecturer, and teacher*”. His renowned humour was exemplified when presenting himself for a Great War field-posting as “*Baby specialist, but I’ll give up infantry and take to adultery*”.²¹

“insufflation anaesthesia” techniques (see Footnote 5), this new IPPV option was most welcome, at a time when other proposed solutions involved more extreme manoeuvres,^{26[chap.VIII]} such as the differential pressure ventilating chamber that Willy Meyer was investigating (also Ferdinand Sauerbruch’s subatmospheric “pressure chamber”,^{28[chap.IV-V]} which he introduced in the new century), or the positive-pressure head boxes of Brauer and others.²⁶ Practical employment of the proposal from Matas^{29[p.223]} enabled Frederick Parham to resect a chest wall sarcoma on 6 August 1898, in an operation both Matas¹⁰ and Parham^{29[p.223-4]} described as revolutionary for thoracic surgery. They both emphasised their endorsement of Fell’s principle of IPPV, but of course its application was rendered considerably safer by O’Dwyer’s improvements. Yet it does not appear the Fell–O’Dwyer apparatus was adopted in Europe (see Footnote 6).

Matas^{10[p.1471]} found similarities to the Fell–O’Dwyer apparatus in Eugène Doyen’s experimental system, reported in 1897, but was inclined to think Doyen was unaware of O’Dwyer’s apparatus. In fact, it is Doyen’s “simple and reliable” system that Matas^{10[p.1469]} describes as “the first finished model of an intubating and insufflating apparatus for the systematic application of this treatment as a preventive of pneumothorax [during thoracic surgery]”. Apparently though, Matas considers it was not used on humans.^{10[p.97]} (In the 18th and 19th centuries, innovative suggestions seemed able to be readily published for promotion, without the author having made his own prior clinical confirmation of them.)

Mushin and Rendell-Baker, in their masterly and well-illustrated 1953 history, *The principles of thoracic anaesthesia past and present* (now reprinted by the Wood Library–Museum, 1991, as *Origins of thoracic anaesthesia*²⁶ — with “contents untouched”), describe what appears to be the pioneering intrathoracic operation with IPPV on a human:

Footnote 4. *The Matas papers*^{1,10,22} supply us with many names of pioneers in intubation and lung inflation from the 18th century onwards, too often forgotten today. Matas then acknowledged independent, experimental work (which was separate from the F–O’D apparatus) on direct intralaryngeal inflation of the lungs for the intrathoracic problem. Although this took place from, especially, 1896–1897, it also went back at least to 1872. Matas^{10[p.1468]} cited successively Péan, 1872 (unsuccessful); Lambotte; Délorne, 1897; Milton, 1897 (successful, but for a goat^{23,24}); “Tuffier, Quénu, with their associates Hallion and Longuet, and Doyen”.^{22[p.430-1]} Even in 1902, Matas^{10[p.97]} could not see any safe, simple and reliable alternative to the Fell–O’Dwyer apparatus in Europe, except Doyen’s — for which Matas stated (1902) no clinical use was documented.

(Notes: Jules Péan, 1830–1898; Albin Lambotte, 1856–1912; Edmond Délorne, 1847–1929; Herbert Milton; Théodore-Marin Tuffier, 1857–1929; J. W. Hallion, 1862–1940; Eugène Doyen, 1859–1916; Eduard André Quénu, 1852–1933; F. Longuet. Péan was immortalised in Henri Toulouse-Lautrec’s painting, *The tracheotomy*.)

they cite M–T Tuffier and L. Hallion for a successful partial-lung resection in 1896.^{26[p.46]} Using the anaesthetic technique of “one of us” (described so by Tuffier and Hallion, in translation), with which they had “previously experimented in animals”, a technique in which rhythmic inflation of the lungs with bellows and a kind of positive end-expiratory pressure,²⁶ which they called operative “artificial respiration by insufflation” (see Footnote 5), produced “rhythmic inflation”. This was before Parham’s 1898 thoracic operation using the Fell–O’Dwyer apparatus (and also before the mediastinal operation of Herbert Milton, MRCSEng, 25 January 1897, who was ready to apply IPPV per bellows via a tracheotomy, but neither intervention was needed^{23,24}).

From a historical viewpoint, Matas^{10[p.1375]} regarded a rhythmic inflating device for neonates employed in Berlin, 1870 (and documented only in German³⁰) by a “Dr Truehead” (who later returned to Galveston, Texas), as in principle a

Footnote 5. *Re “Intralaryngeal insufflation”:* One has to read carefully to see what each writer means by “insufflation” (and contrast it with “inhalation”). In Matas’s time, the word might be used in the broadest sense of getting a gas or powder into a body cavity, and he applied that expression’s action to the Fell–O’Dwyer apparatus, also to “tracheal insufflation with a bellows”. However, flow with the Fell–O’Dwyer apparatus was not continuous but intermittent, so it was really providing forced respiration (intermittent positive pressure ventilation). Matas’s 1900 phrase may surprise some of us today, familiar with Mushin and Rendell-Baker’s²⁶ careful, more specific delineation (first from 1953, then repeated by Mushin, in 1963²⁵) of continuous flow, as below, which derived from developments in the method for insufflation, 1907–1910 (mentioned later). American anaesthetists, 1910–1926,^{27[p.4]} then came to favour a continuous insufflation method rather than the struggling, parallel developments attempted for positive pressure ventilation^{26[p.52-66]} — apart from with the proven Fell–O’Dwyer apparatus.

Insufflation was described thus:^{25[p.13]} “a catheter, generally with a bore rather small compared with the trachea, is inserted down to the carina and a constant stream of gases blown through it, so that a pressure of about 10–20 cmH₂O is registered in the manometer on the apparatus. The gases escape to the exterior between the tube and the trachea” [compare the Fell–O’Dwyer apparatus: expiratory gas returned via the wide intralaryngeal tube]. “In effect the conditions produced are those of positive pressure spontaneous breathing” — although apnoea may almost develop. With the inevitable respiratory acidaemia, practice was, every 2–3 minutes, “to interrupt the flow ... at regular intervals, and to allow the lungs to collapse”.^{25[p.13]}

(Also see reference 26, pages 67–77.)

Footnote 6. *The communication lag that resulted in some medical advances made in one country (eg, the United States) being unknown in another (eg, Germany) is apparent from surgeon Ferdinand Sauerbruch (1875–1951) writing (exaggeratedly, as it proved) in his intriguing autobiography:* “In 1902, not one doctor in the world knew how to operate with any hope of success through the chest wall ... pneumothorax killed the patient immediately”.^{28[p35]} Reciprocally, the same applied for the lack of some European knowledge in the US, such as the direct laryngoscope of Alfred Kirstein (1863–1922) in Berlin, invented in 1895 — a time when most surgeons (ignorant of O’Dwyer) shrank from attempting laryngeal intubation as impossibly difficult.^{26[p.48]}

Box 1. Clinical applications of the Fell–O’Dwyer apparatus reported by William Northrup, 1896¹¹

Patient I. Brain tumour, apnoea; 25 hours’ forced respiration, multiple rescuers; given up. (O’Dwyer and Northrup attended.)

Patient II. Acute opium poisoning, deep coma, apnoea; about 3 hours’ forced respiration; recovered.

Patient III. Ditto, breathing (4 breaths/min), cyanotic; “not severe”, only 20 minutes’ forced respiration; recovered.

Patient IV. Cerebral haemorrhage, coma; trephined, breathing (4 breaths/min); 1–1½ hours’ forced respiration (?abandoned); died.

Patient V. Brain trauma, coma, moribund, breathing (4 breaths/min); 8 hours’ forced respiration, but then became asystolic; died.

Patient VI. Cerebral haemorrhage, coma, apnoea, operated; 6 hours’ forced respiration; died.

Patient VII. Acute morphine poisoning (12 gr = 778 mg), breathing (4 breaths/min); intubated, 7¼ hours’ forced respiration; recovered.

Patient VIII. Ditto (30 gr = 1.94 g), apnoeic, cyanosed; intubated twice for 9 hours total, forced respiration time not given; recovered.

Four patients survived, but they were ones with opiate overdose alone, and not cerebral catastrophes. Voorhees described patients VII and VIII having “*very bad ones* [poisonings], *almost in extremis*”. Northrup noted for Patient VII, “The stomach tube and laryngeal tube ... were in position and in use at the same time”; and for Patient VIII, that it took an hour to get the stomach tube down the oesophagus, past the laryngeal tube.

complicated anticipation of the Fell–O’Dwyer apparatus. He labelled the latter “the second American [IPPV] invention” — as he regarded “Truehead’s” system as “entitled to precedence over [O’Dwyer’s]” (see my previous discussion of Dr Charles Trueheart versus “Dr Truehead”³¹).

We can note that in 1910 Fell asserted⁸ that his own endolaryngeal tube for the Fell–O’Dwyer apparatus was superior to O’Dwyer’s, which may indicate that Fell’s was available and possibly used in some places in the United States at that time; but I cannot find Fell’s design of his own tube for the apparatus, 1910,^{8(p.580)} documented elsewhere.

Clinical application of the Fell–O’Dwyer apparatus

O’Dwyer, while mentioning only a single clinical experience using the Fell–O’Dwyer apparatus personally,^{2(p.34)} advocated its value for all forms of narcotic poisoning, by then “amply demonstrated by Dr Fell”; and for conditions involving “*inspiratory muscle ... rendered temporarily as useless, as if paralyzed by spasmodic contractions, such as strychnine poisoning, puerperal and other forms* [of] *eclampsia, and [as already noted] in acute pulmonary obstruction from various causes*”.² With experience of attending 3000 deliveries, O’Dwyer did not promote his IPPV system for apnoea in the newborn, as he considered mouth-to-mouth resuscitation “amply sufficient” for that purpose.^{2(p.34)}

The Presbyterian Hospital of New York, at least, kept one Fell–O’Dwyer apparatus ready; and Northrup reported on its first clinical use there to the 1894 annual meeting of the British Medical Association in Bristol, United Kingdom.¹⁵ He detailed the delivery of 25 hours of forced respiration (supplied by multiple hands — expert, such as O’Dwyer’s, and otherwise) for a woman suddenly apnoeic from presumed intracranial hypertension, attributable to a cerebral tumour. Forced respiration was stopped after 24 hours, leading to asystole 12 minutes later; but further IPPV — or to continue with the expression favoured then, “forced respiration” — restored her heart beat until forced respiration was stopped after a further hour because of her “absolutely grave” prognosis (Footnote 7). (But even in 1896 Northrup was erroneously repeating that “*Dr Fell’s method is identical with that employed in laboratories*”.^{11(p.127)})

Specific use of the Fell–O’Dwyer apparatus at the NYFA does not seem documented.

Northrup’s clinical series with the Fell–O’Dwyer apparatus¹¹

In the *Medical and Surgical Reports of the Presbyterian Hospital in the City of New York* for 1896, Northrup reported the clinical application of the Fell–O’Dwyer apparatus there for the “first series of [eight adult] cases published”, headed by his single 1894 patient already mentioned.¹¹

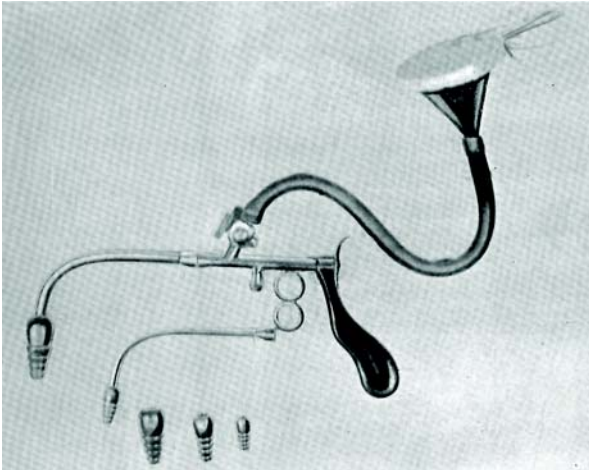
The apparatus must have been ready for that first use when the house physician, “without any experience in intubation of any kind”, performed it “successfully and promptly”, enabling him to supply forced respiration/IPPV by the apparatus. Northrup credits an “HP [or] HS” with initiating the first seven interventions, and “Dr O’Dwyer himself” re-inserted the tube into the eighth patient.¹¹ Further documentation of any other use of the apparatus at the Presbyterian Hospital appears lacking, which leaves one wondering how much further it was applied there — or in other places. Northrup appeared to be the strong advocate for its use in intracranial disasters, with O’Dwyer participating, for example for Patients I and VIII. Brief details of the eight patients are shown in Box 1.

Northrup concluded that the Fell–O’Dwyer apparatus:

- Is efficient for prolonged artificial forced respiration;

Footnote 7. *Flagg*,^{3(p.12)} in later referring to presumably this same patient (as he identified her as the one presented to the “British Medical Society”, 1894), might cause confusion by his statement “The patient recovered and lived for quite a period in good health under the care of Dr Flint”; whereas Northrup clearly described her having an autopsy after forced respiration was stopped.

Figure 4. Matas's modification of the Fell–O'Dwyer apparatus for anaesthesia



Matas added a cone with an on-off tap to enable passage of anaesthetic supplement into its delivery tube; also a pistol-shaped handle for easier control. The bellows delivers inflating air, with or without anaesthetic gas. (With acknowledgement and thanks to the American Medical Association for this illustration from JAMA 1900 (9 Jun); 34: 1472, Figure 11).

- Is especially suitable for opium overdose — here it “certainly saved three lives”;
- Prolongs life (temporarily) in cerebral disasters with apnoea;
- Offers great promise in “operation-theatres ... [for] sudden failure of respiration”; and
- Is a tactile technique of intubation that can be successful without previous practice (or presumably, a laryngoscope also) (see Footnote 8).

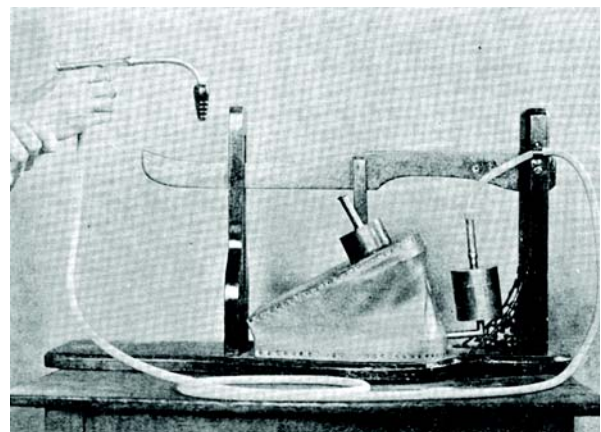
Further modifications to the Fell–O'Dwyer apparatus

While steadfastly maintaining the *principles* set forth for the forced respiration form of IPPV, first by Fell, then O'Dwyer, subsequent developers modified the pump and other *components*, rather than continuing with a form identical with O'Dwyer's original Fell–O'Dwyer apparatus. Thus:

Footnote 8. Voorhees had already claimed his case reports showed “how easily the tube and bellows can be used”.⁹ This tube for the Fell–O'Dwyer apparatus was longer than the smaller O'Dwyer tube for diphtheria. O'Dwyer himself had expressed concerns over difficulties in intubating with the latter, in discussion at an 1887 New York meeting.^{32[p.318]} (But Northrup, speaking after him, reminded the select audience that they, like he, “in the aggregate used the tube several hundred times and had never met with untoward accidents”.^{32[p.319]})

- 1900, a modification by Matas¹⁰ enabled anaesthesia to be incorporated into IPPV when required (Figure 4): a sidearm to the cannula had a rubber tube and funnel attached for administering the anaesthetic agent. The handle was now “shaped like that of a pistol” for better control. And a manometer enabled better control of inflating volumes.
- 1900, Dr JD Bloom's “adaptation of the O'Dwyer intubating canula for intraglottic insufflation in the treatment of asphyxia neonatorum” had “a syringe rubber bulb with a valve at its free end to permit the entrance of air”, illustrated by Matas (as his Figure 3).^{10[p.1374]}
- 1900–1902, Bloom's modification of the original Fell–O'Dwyer apparatus had labour-saving additions (Figure 5), all illustrated by Matas (as his Figure 10),^{10[p.1472]} such as a long lever for compressing the bellows; an in-line air filter; also a source of oxygen for inflation in asphyxia.
- 1902, Matas and Bloom, with the aid of engineer Dr John Smyth, while retaining O'Dwyer's intralaryngeal tubes, replaced the bellows which they considered inadequate, with an “experimental automatic respiratory apparatus” because of “certain conditions met in surgery which differ radically from the conditions met in purely medical cases”.^{11[fig.3,4]} Matas described its use only with dog or cadaver, not live patients. In fact, Anthony Dobell noted (correctly?) that Matas “apparently did not use the apparatus on patients himself”.²⁴ (Matas is much revered in the US, for example as the “father of vascular surgery”.³³)

Figure 5. Bloom's modification of the Fell–O'Dwyer apparatus for anaesthesia



This model can inflate with oxygen. It has additionally a long lever to ease the exertion of compression of the bellows by foot (or hand), and also a cylinder of filtering cotton in the circuit. (With acknowledgement and thanks to the American Medical Association for this illustration from JAMA 1900 (9 Jun); 34: 1472, Figure 10).

It is unclear not only how widespread was use of the Fell–O’Dwyer apparatus, but also how much — or how little — *unrecorded* use was happening in the US, where acute opium poisoning was not uncommon. Were others not treating that, or other respiratory insufficiency such as suffered by several of Northrup’s “neurosurgical-type” patients, by any better method than arm and chest manoeuvres? Was Sir Victor Horsley’s advice^{34[p.763]} not heeded for neurosurgery, or were Northrup’s case-example treatments¹¹ not imitated by others? How much use for thoracic operations followed Parham’s initial operation? Research may establish the answers. If Matas had not written, 1899,^{22[p.430]} that Bloom first introduced the Fell–O’Dwyer apparatus to the Charity Hospital of New Orleans, we would hardly have known of its use (presumably²²) other than at New York or Buffalo, or by Matas and Parham elsewhere in New Orleans. Concerning “*acute opium poisoning, for which [the Fell–O’Dwyer apparatus] is admirably adapted*” and “*used thus far most extensively*”, Matas declared it had “*already saved several lives in the practice of [Bloom’s] Hospital*”.^{22[p.430]} And although LR Hutson and C A Vachon confirmed “*For years the Fell–O’Dwyer intubating canula had been used for the treatments of nonsurgical opium narcosis and of acute obstructive laryngitis in diphtheria*”, their further statement, “*as well as in the resuscitation of drowning victims around the country*”,^{33[p.888]} needs confirmatory data.

Instead of favouring the Fell–O’Dwyer apparatus, the continuous intratracheal insufflation, which US anaesthetists preferred, is considered^{27[p.15]} to have been introduced to anaesthesia, 1907, by “Barthélemy et Dufou (de Nancy)”³⁵ (Footnote 9), following their documentation of it for a mandibular hemi-resection, even though its nature was “assisted respiration” — today’s ventilatory assist. Yet NA Gillespie^{27[p.15]} describes these innovators “apparently unaware of the work previously done in Scotland, Austria, Germany, and Holland”. However, “continuous intratracheal insufflation” flourished for thoracotomy, especially after the boost from its first successful clinical application on 20 February 1910³⁶ by Charles A Elsberg (1871–1948) (acting anaesthetist,^{36[p.27]} subsequently, neurosurgical pioneer), following on his own and others’ experimental work (Footnote 10).

Footnote 9. Even their original paper does not supply the forenames or initials of this pair. With each spontaneous breath of the patient, their endotracheal system³⁵ allowed ventilatory assist, from squeezing a hand-bulb (“*La soufflerie était actionnée à chaque inspiration*”) in circuit with a chloroform inhaler, thence to the endotracheal tube, to free the face area for surgery. So it was intermittent inflation, hardly insufflation but intermittent positive pressure ventilation, to maintain “*A constant partial distension of the lungs*”,^{27[p.4]} interrupted every 2–3 minutes.

In the first decade of the new century, there were many other experimental efforts in the US (also in Europe where, however, Sauerbruch’s influence dominated for the earlier decades), to produce a satisfactory IPPV system for thoracic surgery, well described in the authoritative and detailed accounts for this historical period from Mushin and Rendell-Baker.^{26[chap.VIII]} Innovative investigators before the Great War included L Brauer, S Robinson, FT Murphy, W Meyer, F Kuhn, H Brat and V Schmeiden, NW Green and HH Janeway, Låwen and Sievers, GM Dorrance, JH and AB Dräger, M Tiegel, F Lotsch, S Bunnell and H Morrison Davies.^{26[p.66]}

Were Fell and O’Dwyer intensive therapy pioneers?

The answer needs to be “yes,” from both adult and paediatric standpoints. Both men produced appropriate instrumentation for their treatment by renewed methods, but for many years they had to battle disbelief, derision and opposition to establish their claims — Fell largely alone;⁵ O’Dwyer with the strong support of colleague and key player Northrup, and through the enthusiastic take-up of his methods by others, such as Frank Waxham.^{13[p.162],32}

Initially, George Fell adopted from the animal laboratory a system proving to be clinically successful in saving lives by [re-]introducing positive pressure ventilation.^{4,8,39} He used it primarily for adults critically ill from opium poisoning, but also for a few cases of paediatric ventilatory failure, even in newborns. Fell strove valiantly by example, lectures and writings to popularise his successful Fell method. Part 1 of

Footnote 10. In consecutive articles in the 1911 *Annals of Surgery* [52: 23-9 and 30-3], acting anaesthetist Charles Elsberg (1871–1948),³⁶ then surgeon Howard Lilienthal (1861–1946),³⁷ claimed their operation of 20³⁶ or 21³⁷ February 1910, employing Elsberg’s modification of the Meltzer-Auer animal apparatus,^{36,38} was “the first case of thoracotomy in a human being under [ether] anesthesia” [for a “foul and septic lung abscess”³⁷ by “continuous intratracheal insufflation of air (Meltzer)[sic]”, as Elsberg called it.³⁸ By means of foot-bellows his apparatus blew an (occasionally interrupted) air and ether stream at 15 mmHg pressure³⁶ through a tracheal catheter, of half the trachea’s diameter; the method was then used for other patients.³⁶ Although Elsberg quoted his own and Alexis Carrel’s experimental groundwork for “the Meltzer method,” and although other originators were even earlier, he acknowledged physiologist Samuel Meltzer (1851–1920) and his physician son-in-law John Auer (1875–1948) for their work on curarised animals, 1909. (Without any normal or artificial rhythmical respiratory movements, the lungs were kept in continuous inspiratory distension, interrupted every 2–3 minutes.)

Historical note. Elsberg’s electrically-powered, clinical apparatus, in readiness at the patient’s bedside,^{36[p.26]} already had its first clinical usage on [?]25/26 December 1909: for a medical patient, a myasthenic woman suddenly totally apnoeic. When deemed “hopeless after 6 hours of continuous intratracheal insufflation”, she was allowed to die.^{36[p.25-6],38[p.495]}

this current trilogy of papers documents his pioneering role.⁶

Joseph O'Dwyer took Fell's method and improved it by adapting his own airway tubes to it, increasing its safety, and widening its applications. The subsequent Fell–O'Dwyer apparatus further diversified the capabilities of that method by opening new fields in anaesthetic IPPV, most strikingly for thoracic surgery, and in rescue IPPV, such as for intracranial disasters.

But what he is more famous for is probably O'Dwyer's dedication to the problem of children dying from obstruction of the larynx by diphtheritic pseudomembranes, at a time when the only possible alternative treatment by tracheotomy still left a very high mortality rate. O'Dwyer pioneered intubation directly through the larynx, but significant success with that deadly disease came only after almost a decade of painstaking research, developing and refining his personal method. Thus, where others had failed, O'Dwyer established the intensive care principle we use today of intubation for acute airway obstruction (such a relief for the fearful parents of O'Dwyer's patients, because it avoided the surgery needed for tracheotomy) (see Footnote 11). Yet, despite O'Dwyer being frequently described as "the inventor of intubation" (eg, by JJ Walsh⁴¹), he was the *re-introducer*.

Although the "O'Dwyer principle" was established for diphtheria, the development of diphtheria antitoxin, then toxoid, early in the 20th century much reduced this need for his instrumentation. However, according to the Dittrick Medical History Center, Cleveland, Ohio, his "intubation instruments did not disappear from the medical scene [in immunised communities] until the mid-20th Century".^{20,42}

While Fell advocated the possibility of his Fell method for intrathoracic surgery,³³ O'Dwyer's invention and Northrup's publications both showed Matas the practical way there. This resulted in application of the Fell–O'Dwyer apparatus (although it had, as Matas put it, "originated in other sources")^{10[p.1375]} to prevent the problem of surgical traumatic pneumothorax, unresolved hitherto, and allow safe chest operations.

Rudolph Matas^{10[p.1375]} summarised O'Dwyer's place thus: "*It is to O'Dwyer, therefore, that the greatest credit is due for establishing intubation in its present form, and it is due to his unswerving and indefatigable perseverance, patience and mechanical ingenuity that the present form of [Fell–O'Dwyer] apparatus has attained its marvellous efficiency*".

Footnote 11. Rudolph Matas compiled an impressive list^{10[p.1373]} of dedicated, earlier intubators, from John Hunter and Monro Secundus onwards, including especially the numerous 19th century neonatal interventionists who intubated apnoeic newborn, defying the strictures which were a reaction to the adverse findings of JJ Leroy d'Étiolles, F Magendie and A-M-C Duménil, 1827–1829.^{10[p.1373],40[p.222]}

And "*by similarly transforming the tracheotomy canula of the [Fell] insufflating apparatus ... for ... opium narcosis he has opened a new chapter of still greater interest and promise than that which his previous achievements had brought to a close*". (The meaning Matas implied for "insufflation" was not the same as that of later anaesthetists.)

A last tribute to O'Dwyer^{17[p.562]} is appropriate for his outstanding personal qualities, which come through in articles about him (some are so adulatory they seem hero-worshipping). Thus: "*O'Dwyer left a memory among his colleagues of a purity of character, an uncompromising honesty and uprightness that was almost childlike*". So let us note Northrup's final word: "*... with this genius, there was all that goes to make a man*".

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