Intubation ... was perfected through the conscientious labors of the self-sacrificing Joseph O'Dwyer whose name stands with those of Semmelweis and Crede as the greatest benefactor of infant life.

Fielding H Garrison (1913)¹

It is no exaggeration to say that George Fell was the pioneer of long-term ventilatory assistance.

Michael Goerig et al (1987)²

The beginnings of intensive care medicine (ICM) more than half a century ago lay in meeting the need for ventilatory support in life-threatening impairment or failure of spontaneous breathing. The foundations of that service featured twin interventions: endotracheal intubation and IPPV (intermittent positive pressure ventilation). However, more than half a century earlier, during the 1880s, George Edward Fell and Joseph O'Dwyer identified the need for such intervention and devised, introduced, used and further developed equipment to meet it. The above quotations certainly have elements of truth, and we can acknowledge Fell and O'Dwyer as pioneers who anticipated the further development of IPPV. Although the invention of apparatus for intubation and for IPPV represented significant advances for anaesthesia, in the first instance these devices were designed for intensive-therapy-type interventions on patients critically ill with life-threatening conditions.

Joseph O'Dwyer and George Fell have both been regarded as pioneers by other specialties: O'Dwyer by paediatricians and otolaryngologists; Fell by anaesthetists, especially thoracic anaesthetists, and so also by thoracic surgeons. It is time their ICM credentials were recognised within our own specialty, and we claimed them back as ICM heroes; their individual and joint stories have been told before, especially O'Dwyer's, but apart from Fell's own publications there appears to be limited writing about his work. Most texts of anaesthesia history make only perfunctory, if any, reference to these pioneers, though they occasionally receive fuller attention.²³ usually in terms of the apparatus bearing both their names (the Fell–O'Dwyer apparatus). I aim to detail the pair's use of their equipment for conditions that we treat today in the intensive care unit.

And there is a third man to be honoured: William Perry Northrup, O'Dwyer's enthusiastic supporter, who was involved early in ICM-type cases, utilising the combination Fell–O'Dwyer apparatus.

This essay will appear in two parts, the first devoted to George Fell, describing his landmark IPPV case in 1887,⁴

ABSTRACT

For three decades after Marshall Hall's 1856 strictures against "forcing methods" and bellows for artificial ventilation (AV), human "forced respiration" (equivalent to intermittent positive pressure ventilation) was virtually abandoned. Various arm–chest manoeuvres often proved inadequate to save life. After doctor and engineer George Fell, of Buffalo (New York) (1849–1918), failed to save the life of an opiate-poisoned patient using Silvester's popular method, he resolved to try his animal laboratory AV method (bellows and tracheotomy). Following his first success in a landmark case (1887), he better adapted the apparatus for human use and soon succeeded with further difficult cases, but was unable to raise enthusiasm for his "Fell method" of AV. His reports of successful rescues to prestigious Washington Congresses met derision (1887) and indifference (1893), although by then they detailed 28 "human lives saved", mostly after opiate poisoning, and a switch from tracheotomies to face masks (simpler, but with a few complications).

Continuing with rescues throughout the 1890s, Fell personally achieved recoveries after AV for as long as 73.5 hours (1896), and over 78 hours (1899). He argued for his method repeatedly with many talks, much documentation, and pleas for its use in other ventilatory crises. Despite his endeavours and successes, Fell was unable to secure widespread uptake of forced respiration, but others adopted his principles. Joseph O'Dwyer modified Fell's face mask–tracheotomy system by incorporating an intralaryngeal tube, and this "Fell–O'Dwyer apparatus" was used for neurosurgical cases (1894), also revolutionising intrathoracic surgery (1899).

his other "forced respiration" patients,⁵¹⁵ his practice, and his place in ICM history. His achievements are summarised in Box 1.

George Fell: a brief biography

George Fell (Figure 1⁶) was born in Chippewa, Ontario, Canada, on 10 July 1849,¹⁷ and initially qualified as an engineer at the University of Buffalo, New York. By age 20, he had "placed [the] first crib of the great Buffalo Break-
A decade later in 1879, he was an organiser of the first American Microscopical Congress and a founding member of the American Society of Microscopists, then for 9 years its first treasurer and custodian. Besides working as assistant US engineer on the Ontario–New York State International Bridge at Buffalo (1879), he graduated in medicine “with highest honours” from the University of Buffalo in February 1882; his thesis was Histology of aneurismal clots. In 1884, he was elected to the Chair of Physiology and Microscopy at Niagara University (1885–1895). From his experiments with dogs that developed apnoea from an excess of anaesthesia, he became “conversant” with a method of applying IPPV with household bellows through a tracheotomy, the procedure Fell came to call “forced respiration” (FR), “to distinguish it from the ordinary methods of artificial respiration”.

With that experience, Fell considered that “if the respirations could be kept up by suitable means for a sufficient time to permit the elimination of the poison, life might be saved” — the ICM tactic now used for human opiate overdose.

The details of Fell’s first case on 23 July 1887, with its “saving of a human life”, seem remarkable. After that success, throughout the next 13 years, Fell doggedly documented in meticulous detail his clinical rationales, his apparatus, his successes and his progress using FR (by what he called “the Fell method”) for over 30 other patients, including some reported by others (Appendices 1 and 2). Nonetheless, he suffered disappointing setbacks from severe criticism, and great derision on presenting his pioneering case on 7 September 1887 at the 9th International Medical Congress held in Washington.

By June 1891, although he could claim FR was “at last beginning to be noticed both on this and the other side of the Atlantic [Paris]”, its uptake in his own country was limited, though apparently well enough known in Buffalo. From his account, he was still highly frustrated by the time of his poor reception during the Pan-American Medical Congress, 1893, when presenting 28-plus case histories. Two spectacular cases were documented in 1896 and 1899. Fell did not appear to feature again in medical literature until 1910, when he produced two articles, the last I could locate. Eight years later, after several years of bad health, Fell died, with the causes variously given as “of paralysis”, or “dilatation of the heart”. A medical obituary could claim, “He gave his [FR] discovery to the cause of humanity and has made nothing from his work”.

Besides his pioneering medical work, Fell also continued contributing to engineering projects, some amid controversy, and some of great financial value to government agencies. These are mentioned in his obituary in the Buffalo Medical Journal (as the journal that featured his original medical triumph was renamed). Fell was also inventive. In 1888, a New York State “commission … asked Dr George
Fell of Buffalo to redesign [Harold] Brown’s electric chair”, as yet unused.19 Because Fell’s interest was a humane one, he conducted the preliminary scientific, animal “vivisection experiments” necessary, and after the first punitive electrocution (of a condemned murderer, on 6 August 1890), the remark, “The man never suffered a bit of pain!”, was attributed to “George Fell, executioner’s assistance [sic] to first electrocution” (yet the first, botched application of electricity to the prisoner had needed repeating).20 His other accomplishments included the first “simple, inexpensive practical submarine life-preserver using a face mask”,17 one “whereby an individual may remain under water a considerable time without danger”.18

Fell’s landmark IPPV case

In 1886, “opiates could be freely purchased by the public”.21 Three years later, Fell recorded that, for “the many cases of morphine poisoning, reported almost daily through the press, from San Francisco to Portland, Me.[sic], in which it has been frequently stated that every means was taken to save life (except forced respiration)”, physicians were starting to recognise that his FR could be life-saving. However, they “generally fail to be forearmed”.7[p.377] Another 3 years later, “the old methods [of artificial respiration] have failed” for drowning as well as for narcotic poisoning.9[p.130]

On 22 June 1886, Fell along with other physicians attended the attempted resuscitation of a man who had taken an overdose of morphine, for whom conventional measures, including “artificial respiration by Sylvester’s [sic] method”, failed to prevent “the inevitable. At this time, I [Fell] felt keenly the inadequacy of the methods at our command, and then resolved, if opportunity ever offered, to make the operation … which … might have saved Mr Dyke’s life”.4[p.147] (Fell used “making an operation” as his regular term for applying FR.) He later wrote5[p.41] that he made this resolution “then and there”, at the time of the failed resuscitation of Mr Dyke, and “thoroughly considered it, for fully a year”.8[p.326]

From his foundation Chair of Physiology and Microscopy in the Medical Department of Niagara University, Fell had, over 8 years,9[p.180] “many times”6[p.58] had practical experience with artificial ventilation for anaesthetic-induced breathing failure in laboratory dogs, and also in FR for these dogs pre-terminally, with “the thorax opened for exhibiting the thoracic viscera in action”. The artificial ventilation was by an FR method taught there for 20 years,6[p.55] but Fell observed he had “never heard it even hinted that a human life might be saved by the laboratory methods”.9[p.180] His department’s method of FR for animals required a simple fireside bellows with the nozzle ligatured into the trachea,6[p.53] but Fell wrote that in the laboratory he always used foot bellows.6[p.55] Rubber tubing connected the bellows to a cumbersome and weighty6[p.55] “one piece” unit, comprising a directional control valve and a large, brass tracheotomy tube.15[fig.12] The stopcock on the troublesome valve (illustrated in his 1910 article in Surgery Gynecology and Obstetrics;15 Figure 2A) had to be turned by hand for each inspiration and again for each expiration, wrenching the trachea with each movement.

Although Fell was “unable to find a case in which forced respiration has been used upon a human subject in opium poisoning”,4[p.148] he believed that FR could be used. “The prevailing opinion at that time was that the air vesicles of the lungs would not resist forcible mechanical measures in artificial respiration”.13[p.760] Fell attributed such dogma to the currently held strictures of Marshall Hall, “the highest accepted authority”,9[p.180] to avoid “the use of ‘bellows
any forcing instrument”5[p.325]22 (Footnote 1). Although it appears he made no actual advanced preparations, Fell mulled over his ideas of intervention for a year.6[p.326] Then on 23 July 1887, he was called to a man, a near-alcoholic, deeply narcotised from opium poisoning. Fell’s management produced a landmark case in the history of IPPV and ICM: he later claimed that the application of FR “per tracheotomy in the treatment of narcotism from opium or morphia appears to be original with myself”.6[p.40] His success, after artificial respiration by others present had failed (Footnote 2), demonstrated the possibility of saving a life by FR without the feared destruction of the “delicate vesicles of the lung”. Fell frequently mentions the contrast between the entirely passive FR patient, and the artificial respiration one — “tugged, squeezed, and rolled about, according to the method employed”.

The case history
Fell and others attended “Mr PB” about 7 hours after the latter had ingested morphine (later estimated to be 20 grains [1296 mg]) “and some chloral”.4 Fell first tried simple measures, including dressing the patient and force walking him in the cold air (a move also used for barbiturate poisoning, 1940–1950), then resorted to Silvester’s artificial respiration until too exhausted, so eventually gave up his efforts. With PB’s respiratory and pulse rates at 5 and 200 per minute, respectively, the doctors declared him unable to survive, last rites were administered, and the death certificate started in anticipation. Fell left after about 5 hours’ care in all. Later, Professor (of Materia Medica) FR Campbell was called and found PB still alive, breathing once a minute, respectively, the doctors declared him unable to survive, last rites were administered, and the death certificate started in anticipation. Fell left after about 5 hours’ care in all. Later, Professor (of Materia Medica) FR Campbell was called and found PB still alive, breathing once a minute, so had Fell wakened (after less than 3 hours’ sleep). When they noted the patient’s pupils at the near-final stage of the “dilatation of asphyxia”, Campbell observed, “We can do nothing more”. Fell then offered to try the methods he knew from use on dogs, and went to his nearby laboratory, returning with a “tracheal tube covered with dog hair and blood”, fresh from “electrical experiments [perhaps his electric chair ones?] on a dog … a few days before this”, which he cleaned. With further assistance now available, he performed a low tracheotomy, during which (he later said) “I felt that I was making the operation upon a cadaver and worked accordingly”, also “placing with the greatest difficulty” a ligature around the trachea to seal off the upper airway from below. The patient was then very dusky, while Fell noted “no respiratory effort had been made for some time”. (One must wonder why the patient had not developed cardiac arrest after all this, but Fell is very firm about his patient’s clinical state.)

After FR was established (with difficulty), PB’s blood became “more arterial”, but no spontaneous breathing attempts were detected for at least 30 minutes more; then “after about two hours’ work … natural respirations [gradually returned to] almost normal”; but the patient could not sustain them adequately because of the handicap to breathing from the small opening in the side of the valve (“one-eighth by one-half inch or one and four-tenths by three-tenths mm”4[p.152]). “Only a small portion of the expired air could pass through it, so that a large percentage had to escape by the side of the canula [sic].”15[p.577] Haemorrhaging from the stoma followed the patient’s restless moving about, but three soldiers living in the house restrained him. After 2.5 hours of FR, the “cumber-some” tracheal tube of the respiratory apparatus was changed for an “ordinary” tracheotomy tube (ie, one with an inner cannula), and spontaneous breathing was allowed. The patient recovered, despite a relapse to breathing at 6 per min about 24 hours after the operation, and a bad attack of delirium tremens. Fell’s very detailed account is fascinating to read.

Fell later wrote “… when I made my first operation it was with incomplete apparatus, and it was surprising on this account that I did not lose the case”.6[p.328] Thus Fell “saved a life which [he] had thought there was no possibility of saving”.6[p.326] His comment over his first case, “Had I failed I probably would have ‘settled’ the question of forced respiration”6[p.328] is reminiscent of what could have happened to Bjørn Ibsen on 27 August 1952 if his intervention of tracheotomy and manual IPPV in a moribund child with polio had failed.

Presentation and documentation
Within 2 months, Fell presented his case to an international audience in Washington (on 7 September 1887),4 “but
received only humiliation”, which he described later in 18918 (Footnote 3).

Four months after this rescue, November 1887, Fell had his case history published (Figure 3), together with certain recommended changes necessary to repair the deficiencies of the animal apparatus. “The laboratory apparatus used at the time merely demonstrated the value and safety of the [FR] principle.” 13[p.760]

**Fell’s conclusions**

Fell arrived at certain conclusions from his successful treatment:6[p.155-6]

- Improvements to his animal apparatus, especially to the valve, were needed to use it on humans — he had them set out clearly by December 1888.6[p.53-60] Also:
  - Cold air could be warmed by passage through a vessel of heated water; and
  - A tracheal tube could be secured in place by annular corrugations or a rubber tampon.
- Pure oxygen is not necessary for breathing failure treated by FR. (He later changed his mind).
- Judgement is needed to prevent overinflation of the lungs.
- The FR apparatus (without its air heater) can be fitted into a portable bag suitable for emergencies.
- Employing his apparatus with a tracheotomy offered, in his opinion, more positive results than it did with intubation of the larynx.

**Footnote 3.** Being “acquainted with but very few individuals [at the 1887 Washington Congress] it was with the greatest difficulty that I had an opportunity to read my paper at all, and what was the most peculiar feature of the whole circumstance was, that, even among a class of men supposed to possess the highest medical knowledge, not any of them saw the point which presented in that first case of forced respiration, in which I breathed for a man two and one-half hours with a tube in his neck. They did not grasp that point. And I now make the statement, without fear of contradiction, that there was not a paper presented at the International Congress at Washington which had a farther reaching import, if to save a human life is desirable, than that little paper on “Opium Poisoning”, which I presented — a paper embodying in it demonstrations which would alter and advance one of the greatest medical practices of the day, a practice of wide application. It demonstrated what was before not practically accepted in medicine, that we could force air into the lungs for an almost unlimited period without danger to the delicate lung tissue …”

“When I managed, however, to read my paper at Washington, they did me the kindness (?) [sic] not to publish it in the proceedings.” (Does Garrison’s15[p.723] citing “Fell: Tr. Internat. Med. Cong. Wash., 1887, I, 237” refer simply to the agenda, then?) In the “brief discussion” following Fell’s delivery, several physicians claimed to him that his FR treatment was not needed, or that Silvester’s artificial respiration would have accomplished as much.6[p.37]

“After I had saved my third life [December 1887], however, by forced respiration, and the world could not question methods which were so positive in their demonstrations, and so undeniably original, there not being a similar case on record … [from discussions with organisers of the Congress, September 1887] … it was evident my paper was either not carefully read, or the principal point conveyed by it was not grasped by the members of the committee.” 8[p.326-7]
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Patient 5, Fell noted the “bellows working at the rate of 108 movements per minute, patient by this means receiving 21 respirations to the minute”.

Further use of forced respiration

In the presence of four physicians on 10 December 1887, Fell for the first time used “his” apparatus (the animal set now refined for use on humans) for a (successful) “difficult case” of laudanum poisoning; but only after long refraining from intervention, for as long as the others thought they could succeed with artificial respiration. “Time was given to demonstrate beyond question the uselessness of the artificial respiration [as cyanosis continued], until it was feared the patient might succumb before the forced respirations could be applied.”

Bleeding, which blocked the tracheal tube, and aspiration necessitated that a second ligature be inserted around the trachea and tightened. “I was urged to discontinue the respirations on account of the case’s being considered hopeless.” He did so at one stage, but “The man was not dead, and we had to keep it up.” After such long hours of work (14.5 hours of FR), Fell suggested that electromotive power be substituted for hand power in future.

In documenting this patient, March 1888, Fell emphasised the curious dissociation of returning consciousness from an unmatching respiratory drive. Presumably to gain extra evidence for his artificial ventilation method, he labelled this FR patient — his second — as “Case 3” of FR (see Footnote 4). Fell called for his apparatus to be used in future.

Footnote 4. Forced respiration (FR) Case 2 (in Europe): Fell cited a successful Viennese instance of FR, 21 September 1887, per tracheotomy for narcotic poisoning, soon reported in the Lancet of 15 October (within “The Medical Societies” [p.776] and very hard to find!), then with more details in 1889 from Professor Boehm. He appeared delighted at the Austrian success of tracheotomy–FR, but without actually claiming credit for it, Fell did not hesitate to state that the Vienna case occurred “after the reports of my first case (read before a section of the Medical Congress at Washington [that September]) had appeared in the medical journals”, although Boehm did not mention either Washington or the Buffalo Medical Journal. Nor did Boehm write that he conducted the treatment himself, so possibly the rescue was through the action of some other person independently of Boehm. At that time, was this FR rescue a unique incident in Europe, or was FR practice better known there? Certainly by June 1891, Fell could find “his” FR being described in the reports of the Paris Academy of Medicine.
cases of drowning, and then wrote “we shall find it a favourable field” for use of FR, again that year.

With the completion of treatment of his next overdose patient, his third successive difficult one, needing 24 hours’ FR, January 1888, Fell had “saved three human lives after all the usual methods had failed”, with “all successful under most adverse conditions”. He later wrote that the efforts for his “second and third cases would surely have failed” if he had not modified his original laboratory animal apparatus. Footnote 5 Fell estimated that his saving of the first three lives represented a $23 000 boon for the insurance companies.

Fell’s very professional report at the end of 1888, taking stock of his patients to date (aged 18 days to 80 years), set out principles and practicalities worthy of an early intensivist: • The 10 essential principles he required for FR in man. • The physical composition of his apparatus (Footnote 5). • The need for suitable timing for intervention with FR, which is something more than a last resort compared with artificial respiration. • The emphasis on the need for preparedness of equipment and teamwork in using it. • The anticipated usefulness of FR for drowning (and almost all cases of asphyxia), when the opposition of the great majority of the medical fraternity to tracheotomy could be bypassed by intubation of the larynx or trachea. Fell carefully described the technique for intubation. • The usefulness in shock, demonstrated in his second and third applications of FR. He implied that FR “may give us results in shock to be attained by no other means, or may serve as an accessory to other methods to overcoming this bane of surgical progress”. For his times, brave predictions indeed.

After publishing his initial two successes, Fell meticulously numbered and documented the subsequent FR patients for which he had details, into successive groupings: what he called Patients 4–6 in December 1888; Patients 7–10 in 1889; Patients 11–22 in 1891 (by this time, with “the saving of fourteen human lives”); Patients 20–25 in 1892 (with now 19 lives saved); and comprehensively, from his presentation to the Pan-American Conference at Washington, 7 September 1893, Patients 1–28 (plus others’ Patients 29–44) in 1894.

Over a spread of 8 years, the journals featuring these case histories were at first progressively more prestigious: the hometown Buffalo Medical Journal was followed by the Transactions of the New York State Medical Association in 1888, 1889 and 1891, the Archives of Pediatrics in 1892, then the Journal of the American Medical Association in 1891 and 1892. Later came the Canada Medical Record in 1894, the Medical Record (Philadelphia, Penn) in 1896 and Medical Examiner (NY) in 1899. Many of the publications appear to have an excess of material repeated from previous reporting, but often that would arise from many articles being textual renditions of addresses by Fell to learned societies. Thus FR Patients 4–6 were published in December 1888, with Patients 1–3 recapitulated; and Patients 1–10 were repeated with Patient 15 in 1891.

Fell’s dismal failure to convince his international audience at Washington in 1887 has been quoted; he was much more reticent about the reception of his 1893 presentation in the same city, the text of which — in the Canada Medical Record — was accompanied by his observation that “the majority of the members of the Congress appear to know very little regarding the work accomplished by the methods described”. He did receive a few appropriate questions and a recommendation from “the worthy president of this body”, but recorded that “No special recognition which has resulted in calling the method into general use has resulted”. In this article, Fell describes most completely the FR patients to date, Patients 1–28, with unhesitating recapitulation from earlier papers; Fell says he “reported in detail simply to silence all doubters”. What became “my method” (first noted in 1891), he changed to the “Fell method” from 1893.

After 1894, Fell did not individually number the multiple patients in his next two articles: one from 1896, describing use of FR for instances of various anaesthetic overdosages (by ether, chloroform or nitrous oxide); the other in 1899. Each article contained a prolonged account of a spectacular and lengthy case. Perhaps the number of patients was becoming too unwieldy to describe each individually, as in May 1896 he wrote (without offering further evidence for the number), “some one hundred human lives, which would certainly have been sacrificed by the methods at the command of the profession at the time, have been saved [since December 10, 1887] through forced respiration. Most of these cases have been saved at my hands with few exceptions in the city of Buffalo”. Fell referred to the “saving of a human life” in all his articles, almost as if by rote, and although it becomes almost irritating it does make his point. By 1899, he claimed FR had “saved a few hundreds of human lives and is destined to save thousands”.

Footnote 5. Fell’s FR apparatus now comprised: • air-forcing apparatus, laboratory, hand or foot bellows, with a rubber equaliser; • air-warming apparatus, per a water-containing copper vessel, and an alcohol heating-lamp; • air-valve, now with a piston instead of a tap to inject a forced breath; • tracheotomy tube and a set of sized, circumferential rings to seal off the upper airway; and • connecting rubber tubes allowing free movement and flexibility. Fell disposed of a second bellows for forced evacuation [as per methods of John Hunter and others] as “a grave defect”. And he devised artificial lungs to study ventilation.
Brief notes for some of the case histories (Patients 1–28) are shown in Appendices 1 and 2 (also see Footnote 6), together with accounts of the two remarkable cases of 1896 and 1899, respectively — remarkable considering their times and the level of medical knowledge then available for treating critical states. After a decade apparently without further writing (see later discussion), what seems to be Fell's last FR medical report appeared in 1910.  

**Critical illnesses in Fell's patients**

The numbered FR patients referred to below are described individually by Fell in reference 12 (also see Appendices 1 and 2). Most of Fell's successes were with “cases of opium narcosis”, and many patients had deteriorated to a truly desperate condition by the time Fell was called. Often other medical attendants had quite written off the patient's chance of survival. Some patients had comorbidity (FR Patient 4 in his reports), or were elderly (Patient 21, 78 years; Patient 19 [HgCl₂ fatality], 73 years; and Patient 5, 80 years). All but one of the first 11 patients were poisoned by opium or its derivatives, and three of these (Patients 1, 7 [fatally] and 9) had near-terminal dilatation of the pupils. Some patients had advanced ventilatory failure with breathing rates of 1–5 breaths per minute (and breathing was described as absent for Patient 1); another (Patient 22) had Cheyne–Stokes breathing; while cyanosis was common. Others had more than ventilatory problems, such as shock for Fell's second success (Patient 3), haemorrhagic shock for Patient 4, some without detectable wrist pulses (Patients 4, 7, 10, 15, 17 and 22), while two patients were convulsing (Patients 6 and 21). Some of the problems resulted from lack of protection of the airway with the use of the face masks, and Fell described severe airway problems for Patients 8 and 21, both requiring ligatures to pull the tongue forward. Patient 18 had anuria, others oliguria.

The efforts of Fell and others at arousing the narcotised were those of the times:

- Emetics were given in the belief that vomiting would stimulate the “benumbed” respiratory centre, where possible by swallowing water and mustard with a teaspoon of salt, otherwise by means of hypodermic apomorphine.
- Gastric lavage (for Patient 5) then, where possible, gastric fluids (even gastric food).
- Repeated enemas.
- Other agents now dismissed (bar the last) might also be used:
  - “Stimulants” such as coffee (about 1 strong pint for Patient 20 after gastric lavage), strychnine, brandy, belladonna, atropia and digitalis.
  - Faradisation, applied only to Patient 15, unfortunately fatally, by a “helpful” colleague after Fell had already rescued her.
  - Bloodletting for Patient 23. Fell regretted he had not provided this in Patient 21 — a 78-year-old who had taken an overdose of gum-opium, with “intense congestion of the encephalonic vessels”.
  - “Saline infusion by the transfusion method” for shock (Patient 4), but that brought later complications.

Misadventure seems to have caused death in at least three patients: Patients 6 and 19 (both irremediable from the prescription errors of others), and Patient 15; but for Patients 18 and 21 death was probably ill fortune.

An entry portal was provided to Fell's FR system to supply (cylinder) oxygen into the apparatus when that was needed, but its use was specified only for Patient 18, and for the two patients who received several days of FR (also see Appendices 1 and 2): Dr Henry Williams, in a “desperate condition”, and Raymond Archer, on whom the “unquestioned practical demonstration of the value of the method” was in evidence — although there was also the “unnerving” complication of rupturing of the bellows during FR which required an [estimated] 525 000 movements.

Fell reported that he was frequently questioned about lung complications, but asserted “in not one of the many cases [with FR for between 2 and 78 hours] has any lung complication of any consequence been produced” — presumably referring to survivors — as “no over-inflation of lungs is produced”. Different complications occurred in Patients 18 and 21, as described below.

**Fell on intubation versus tracheotomy for FR**

After Fell’s experience of his first six FR patients, it must have seemed obvious to him that a factor strongly deterring other physicians from using his method was that it required a tracheotomy, which understandably many would shrink from attempting, or would object to. “Where tracheotomy is necessary, owing to the objection of the great majority of the medical fraternity to cutting operations, it may not be generally used.” So he pointed out early (1888) that in “drowning [particularly] and many other cases” tracheotomy need not be performed, and FR “may be applied by..."
intubation of larynx or trachea" (this was still likely to be a difficult task for most doctors). He then set out clearly the technique of intubating, using a tracheal tube of flexible rubber, and also how to secure it, but did not indicate whether he had already done that himself.

After Patient 15 (March 1891), Fell declared that, based on his experience with a dozen living beings (they could hardly have been only drowning victims), he was not as yet recommending intubation because “there are many cases, in fact [I] have seen many, where it was not practicable owing to the difficulty of intubating the larynx”; and he stated his belief, based on Patient 15, that “in a long continued operation it is possible to breathe for the patient more easily and thoroughly by resorting to tracheotomy” [p.329]. This contradicted the statements of Professor Horatio Wood of Philadelphia when promoting Fell’s method to the Berlin International Medical Congress (25 August 1890). [p.325] There Wood insisted that if there was a failure with the usually satisfactory face mask (described by him as “all that is necessary” for artificial respiration — but only after he had switched to endorsing face masks instead of tracheotomy), an intubation tube could replace it. Fell recognised the dangers of inflating the stomach and intestines when using a face mask (“too great pressure will distend the oesophagus and inflate the stomach and intestines” [p.125]) and soon experienced serious consequences of that for the third next patient, Patient 18.

After Fell’s first successful case, instead of continuing with his earlier “ligature about the trachea to prevent the air from passing up the throat [after the tracheotomy]”, he devised a ring [p.54] (in different sizes: “larger or smaller” [p.346]) to attach near to the tracheal end of the tracheotomy tube (Figure 2B). The ring also aided retention of the tube from its firm fit, and helped prevent aspiration into the lower airway — yet, fatally, such a ring did not stop aspiration in Fell’s FR Patient 18 (1891). Joseph O’Dwyer had promoted laryngeal intubation for FR, by replacing the tracheotomy tube of the Fell system with his own laryngeal tubes, thereby introducing the Fell–O’Dwyer apparatus, as will be described in Part 2 of this history.

Among Fell’s objections to intubation as promoted by O’Dwyer for FR after opiate poisoning was that it “would prevent the imbibing of fluids, through which means we may most readily aid elimination of the poison”, whereas “tracheotomy offers more hope for our patient than intubation, as there is no interference with the passage of fluids to the stomach”. [p.347] (Also it was advantageous against the danger of vomited material entering the larynx.) His viewpoint 4 years later was that “Many lives have been saved by it [face mask or cup] without necessitating the operation of tracheotomy and its use has indicated that intubation is seldom needed, although its value [intubation’s presumably?] must not be lost sight of in forced respiration as I intimated in my first writings upon the subject”. [p.760] With his last publication of new case reports (1899), Fell was backtracking on his earlier advocacy of intubation for drowning too, as “the time lost in attempted intubation in drowning cases would make the operation [of intubation] impracticable”. [p.169] While the value of the face mask was “an hundred fold” more.

Despite Fell’s arguments, the Fell–O’Dwyer apparatus became established, and Fell obviously came to accept it, as he himself designed a rubber tube for it in 1908 — one extending within the trachea and, as he saw it, less injurious than O’Dwyer’s brass tube with its attached vulcanite tip, which did not pass beyond the larynx [p.583] (Figure 2D). (But I cannot find a publication from Fell which mentions that he — or anyone else — used one of his endotracheal tubes.) By 1910, Fell was prepared to rate an intubation tube alongside a tracheotomy tube and an “air cup”, as “all of positive value in forced respiration”. [p.583])

In 1892, by detailing nine points of improvement for the Fell method, Wood rebuffed “Dr. John[sic] O’Dwyer of New York, who has given public utterance to the statement which Dr. Wood first, and I think unwarrantably, urged”. [p.130] Wood had indicated at the Berlin Congress, 1890, that “Dr Fell’s method … [was] identical with that practiced in the laboratories on lower animals”. Wood escaped lightly — in contrast to the unfortunate, savaged O’Dwyer — as, notwithstanding Wood’s remarks, Fell still wished “to again pay his respects [to him]”. But Fell seems to have missed picking up on the repetition of O’Dwyer’s remarks by his supporter Northrup in two of his publications, 1894 [p.25] and 1896 [p.26].

By 1893, Fell had changed his earlier opinions, now largely abandoning any form of intubation for FR, although he conceded [p.125] that he had saved life by performing a tracheotomy “after the face mask has failed in one or two instances” because of heavy opiate narcotisation. And “as to intubation, it may have its place in some cases of forced respiration, but to urge its value over the use of the face mask when the latter has accomplished so much, is unwarranted”. [p.125]

**Fell on face mask versus tracheotomy for FR**

When managing Patients 8 and 9, Fell thrice rebutted “Dr. John[sic] O’Dwyer of New York, who has given public utterance to the statement which Dr. Wood first, and I think unwarrantably, urged”. [p.130] Wood had indicated at the Berlin Congress, 1890, that “Dr Fell’s method … [was] identical with that practiced in the laboratories on lower animals”. Wood escaped lightly — in contrast to the unfortunate, savaged O’Dwyer — as, notwithstanding Wood’s remarks, Fell still wished “to again pay his respects [to him]”. But Fell seems to have missed picking up on the repetition of O’Dwyer’s remarks by his supporter Northrup in two of his publications, 1894 [p.25] and 1896 [p.26].

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**Fell on face mask versus tracheotomy for FR**

When managing Patients 8 and 9, Fell noted that efficacious FR could be supplied — without a tracheotomy — through the tube (from his IPPV apparatus) being sealed into the mouth by closing the nostrils and compressing the mouth around the tube — first for a stillborn infant (Patient 8), then for an adult male (Patient 9). He saw the possibilities of oral FR by face mask, and first prepared one covering both mouth and nostrils (Figure 2C) to enable FR
lasting 4 hours for Patient 11. Fell later revealed that originally the cup he called the face mask “may be made of tin or hard rubber with the edges which are applied to the face or body of wax, which, by heating, will make it conform to the surface of the body”\textsuperscript{15p.581} (Figure 2C). His face-mask system for FR\textsuperscript{12Cp.126} thus came to comprise foot-bellows, rubber tube, air valve, rubber tube, face mask (Footnote 7).

Following Fell’s first face-mask patient (Patient 11), Dr C R Vanderburgh treated Patients 12–14 successfully with face masks, and Fell Patients 15, 17–19, 21, 22, 24 and 25.\textsuperscript{12} However, after Fell re-oxygenated Patient 17 by face mask for 3 hours, she relapsed to cyanosis, pulselessness and inerntness, all of which then indicated “no hope”. That her condition then improved with FR “by tracheotomy over that [FR] produced by the face-mask, was evident”\textsuperscript{8p.185,12p.84}\textsuperscript{12} After using a face mask for 11 hours for his next rescue (Patient 18), the amount of air (and oxygen) forced by FR into “the stomach and bowels was so great as to markedly distend them, thus interfering to a certain extent with the inflation of the lungs”\textsuperscript{8p.186}. A tracheotomy then enabled ready inflation, so after the procedure he handed over further treatment to a colleague and students; the patient vomited forcefully, aspirated vomitus, and “the labor of 18 hours was lost". After using an “easily applied” face mask for Patient 19, he used tracheotomy for the next patient; but in Patient 21 Fell admits “a mistake was made”: he kept persisting with a face mask despite airway difficulty requiring a “coarse” tongue ligature, before resorting to tracheotomy, again after 11 hours, which proved a fatal delay\textsuperscript{8p.188}. For his very next patient (Patient 22), who had Cheyne–Stokes breathing, Fell indomitably proclaimed “the face-mask demonstrated again its great value in a typically appropriate case” and continued using it. He emphasised that he had demonstrated that FR by use of his face masks had saved many lives with “from two to ten hours’ work” without a need for a tracheotomy\textsuperscript{14p.169} (Figure 5).

With hindsight, from a 20th–21st century perspective, one can wonder how appreciative Fell was of the increased risks associated with inflation using a face mask, with the airway left unprotected. Did he discount them because a face mask “brings the operation [of FR] to that degree of simplicity that it may be readily utilized by physicians unwilling to make tracheotomy”?\textsuperscript{12p.83} A few patients suffered typical consequences associated with use of a face mask without intubation: for example, as above,\textsuperscript{8p.186} having air forced into stomach and intestines, with associated mortality — despite Fell’s attempt to prevent this by what could now be called a kind of “reversed Sellick” manoeuvre (Fell quoted Agnew’s surgery volume 3, page 88 as describing “the larynx pressed back against the oesophagus”\textsuperscript{6p.39}). One cannot tell in Fell’s personal cases how much his persisting without a tracheotomy was his sheer determination (and how much of that was just to be right?), or how much was due to his wish to encourage other practitioners to perform FR by their being spared the need for tracheotomy — which the patients were spared also. Although in multiple instances an obstructing tongue was managed with a ligature to pull it forward, there is no mention of jaw lift, or of lateral rather than supine positioning of the patient. Fell does state that extension of the neck was not a completely reliable solution, claiming his tongue ligature had corrected airway obstruction by the tongue in “the few cases”\textsuperscript{10p.348}

Fell developed genuine expertise in the FR method with a face mask, often for prolonged periods, enabling some impressive “saves”. He regretted his choices that proved fatally unwise (Patients 15, 18 and 21). But adoption of his face mask would change a situation from one requiring an immediate tracheotomy on a moribund or dying patient while time slipped away with no lessening of the primary respiratory failure and hypoxia, to one where quickly starting FR per Fell’s face mask relieved the acute crisis, to allow a tracheotomy to be performed more safely.

**Footnote 7.** Regarding use of the face mask to inflate the lungs, Fell wrote\textsuperscript{12Cp.126} “For each three movements of bellows, press down piston of air valve, which permits the air to pass to the lungs, bulging out the cheeks, and produces an inspiration. If cyanosis does not pass away, make the inspiration a little longer. With the air valve you can absolutely control the outward or inward movement of the air, and by watching, if attempts at respiration should be made by the patient, you can materially assist them and change instantly from one to the other.” Thus Fell’s FR form of intermittent positive pressure ventilation could convert to what today we call “assisted ventilation”.

**Fell and mouth-to-mouth rescue breathing**

In a previous article\textsuperscript{27p.228} I questioned whether Fell was aware of mouth-to-mouth ventilation (MMV), but can now note that for “a case of stillbirth” (Patient 8) he stated,
“Previous to my arrival, the nurse had kept up the action of the heart by mouth to mouth insufflation. Cyanosis was extreme. As I did not wish to attempt tracheotomy, for a time I resorted to the same means. This not giving satisfactory results …” He obtained an immediate change by employing FR through a tube sealed into the mouth, and the success alerted Fell to the possibility of FR without tracheotomy. Obviously, both nurse and doctor were familiar with the MMV method. (The ever-optimistic Fell even tried to resuscitate an asystolic stillborn baby, 18 June 1888.6(p.53)) Fell makes no mention of MMV in his 1910 list of methods of “artificial respiration”.15

**Fell’s recruiting of collaborators and disappointments**

It is obvious from Fell’s writings that he endeavoured to spread his message. Once he achieved his own first five successes, he quickly advocated a practice, now an ICM “gold standard”, for when in doubt: “The only safe rule is to make the attempt [at rescue]”.7(p.318) The case histories reveal that he himself could be called upon at any time to go to a patient needing ventilatory assistance (“I have always been ready to aid and assist anyone disposed to utilize the method”11(p.130)), although the calls after an overdose often came well after midnight. He was also prepared to lend his apparatus to experienced practitioners (“in Buffalo my apparatus has always been at the disposal of physicians whom I considered capable of using it”)7(p.317). By Patient 10 of 1889, the apparatus had become commercially available, with “manufacture … by a responsible firm”7(p.318), and Fell tried to ensure that the apparatus available be “in the simplest manner”.9(p.180) After 2 years, he reported, “lives have been saved by several physicians who have used my methods”, although FR “has not yet come into use in [other] fields to which it is admirably adapted”.9(p.176-7) (He indicated in 1896 that “the Fell forced-artificial-respiration apparatus” was held at Buffalo’s Fitch Accident Hospital.13(p.761))

Fell clearly spelt out that, although there was “no impediment in the way of general adoption by the medical profession, no restriction on the manufacture of the apparatus by any instrument maker”14(p.169) proper practice came “only by the skilful use of an apparatus specifically adapted in detail for use upon man, and through practical knowledge which it has taken [Fell] some years to become acquainted with”. He deprecated most fully any kind of FR “committing a woeful sin of omission in turning out students disqualified to practice forced respiration as I have given it to the world” — certainly strong criticisms. And while Fell knew that his method might seem sinful to those

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He criticised Wood for advocating “cheaper apparatus’ with common bellows”10(p.345) but did concede its use for an emergency (although “with a feeling of hesitancy”) if nothing else was available.9(p.183)

After the inspector of life-saving stations on the Great Lakes reported that the tracheotomy needed was beyond the capabilities of the crews of professional rescuers there, Fell advised that the option of the “face cup” was now “the only method which should be used at these stations”, and that method “will accomplish more than the best methods of artificial respiration in use in the past”. He advocated “a ship’s crew [also being] taught to utilise this valuable method of saving lives”.12(p.122) And for further use, “even on the ice, or elsewhere”.8(p.328)

Effective use of any apparatus required it to be available beforehand, yet “physicians will generally fail to be forearmed, even if they have been forewarned”.7(p.317) Although he could report 2 years later that “lives have been saved by several physicians who have utilised my method”,9(p.176-7) apparently that was only for poisoning, not for other needs such as drowning, asphyxia or traumatic shock. And by 1891, he could muse that “with only 5 or 6 physicians of the 90,000 in this country prepared, as far as I know, to use this method, it would hardly do to … now retire on my laurels”.9(p.190) While lamenting how many saveable lives had been lost from the inertia of physicians, in 1899 he was still ruefully commenting, “That it [rescue FR] has not come into general use, can only be through the belief of medical practitioners that it will not accomplish all that I have claimed for it”, although “there is no impediment in the way of general adoption by the medical profession”.14(p.169)

One solution Fell proposed, which evidently fell on deaf ears, was that every medical student in the country be required to know how to use the Fell apparatus.14(p.170)

Fell’s publications repeatedly indicate his disappointment at not being able to penetrate the bulwark of medical conservatism, scepticism, opposition and criticism (eg, of FR as being “unnecessary, useless and unjustifiable”).10(p.342) Many contemporaries could have been put off by the opinionated forthrightness of his messages with such an inconvenient truth — that there were lives out there which could be saved, and were being let go because of timidity or lack of willingness to intervene. But what would have seemed worse — it must have produced outright fury — was his 1899 aggressive accusation14(p.170) of the “almost criminal negligence which has so fully taken possession of the medical profession regarding the value of the Fell method of forced respiration”. Further, a medical teacher was “committing a woeful sin of omission in turning out students disqualified to practice forced respiration as I have given it to the world” — certainly strong criticisms. And while Fell knew that his method might seem sinful to those
respecting Marshall Hall’s views, he declared, “So I am a medical sinner and a bad one, for I glory in my sin, which has now saved a few hundreds of human lives and is destined to save thousands.”

When Fell needed physical help with his own cases, he could call on his students for physical contributions — it seems he formed a band of dedicated assistants, both physicians and students. For his own third patient he class of students aided him throughout the night, six helped for the 1899 patient Archer, “an army” with Patient 18, while other doctors were often in attendance, to an extreme of a named 20 (plus his loyal team of six medical students) for his famous rescue of Dr Henry Williams, 1896. A dozen hours of FR treatment using a face mask must have been very tiring for the operator, and Fell recognised that this human labour, needing an “immense amount of manual energy”, should be supplemented for the physical task. So he had a “blower [unfortunately noisy] for force purposes run by hand and crank power”.

Perhaps he was not able to realise on his 1888 suggestion to substitute electromotive power for hand power.

Wider applications of the Fell method

Fell repeatedly stressed the possible wider applications of his method. Already with the report of his second success, Patient 3, he was seeing the applicability of FR for drowning, and in late 1888 when reporting FR Patients 1–6, he called for his apparatus to be so used; and predicted FR as the most reliable agent “in almost all cases of asphyxia, from whatever causes”. From the usefulness demonstrated for shock in his second and third FR patients, he inferred FR “may give us results in shock to be attained by no other means, or may serve as an accessory to other methods of overcoming this bane of surgical progress”.

In 1891, after crediting FR with saving 15 lives, Fell was forecasting FR for “general use in cases of drowning, shock, the tiding over of critical cases, in asphyxia from whatever cause, as well as from narcotic poisons”. As mentioned, it is not clear whether he ever was able to implement such uses himself. But meantime, Joseph O’Dwyer was developing early improvements on Fell’s original design to widen its applicability (Footnote 8).

Footnote 8. By introducing laryngeal intubation instead of using either a tracheotomy or Fell’s face mask, Joseph O’Dwyer refined Fell’s original FR system into what he courteously named the “Fell–O’Dwyer apparatus” (to be described in Part 2). The first documented case history of its use for a patient appears to be William P Northrup’s, 1894, followed the next year by a fuller description and illustration of the apparatus by James Voorhees. By 1910 at least, Fell had come to accept the Fell–O’Dwyer apparatus with apparent good grace, while still referring to it as “the so-called”.

In March 1896, in the discussion that followed Fell’s reporting in Buffalo on the successful rescue of Dr Henry Williams — who required around 80 hours of FR for opiate overdosing — he received strong medical support (and also his just entitlement to “commendation for his unswerving appreciation of the value of his work”) and the suggestion that the American Medical Association bring the attention of the US government “to the value of Dr Fell’s method as a life-saving appliance”. It appears that, during a time of “unjust and unreasonable conservatism in a progressive age”, nothing worthwhile was taken up. But following his reporting the Williams’ case history, Fell was advocating using FR for more venturesome possibilities “never before contemplated in surgical procedures, such as the opening up of the thoracic cavities under conditions we dare not consider [without FR] ... and in conditions of shock, in drowning, and in many other contingencies”.

Note that this preceded Rudolph Matas’ epiphany in 1897 (“thoracic surgery was on the eve of a revolutionary innovation” over the use of FR for intrathoracic surgery by the intralaryngeal route, to be discussed in Part 2 of this history.

Intracranial disasters and neurosurgery

In a further surgical field, Fell had noted, without supplying the year for it, that neurosurgeon Sir Victor Horsley (United Kingdom) appreciated that with various intracranial disasters, the final common pathway to “death is due to failure of respiration”; and “where death threatens from intracranial pressure artificial respiration should be performed and the skull opened freely”. So “in many instances it is as important to perform forced respiration as if the case were that of a drowning man”.

Fell believed “that in many cases of brain surgery altogether too little attention is given to support by artificial respiration”, but now FR was available to open up new fields. He was at that time aware that Northrup had already applied IPPV for a neurosurgical patient, using the Fell–O’Dwyer apparatus, in 1894, but Fell in his writings never seems to have quoted Northrup’s 1896 Presbyterian Hospital series of 10 critical FR interventions using the same system (Footnote 8).

Intrathoracic surgery

In June 1899, Fell was still lamenting that FR’s “utility in association with surgical operations has yet to come, and surely will do so”. However, he soon must have felt satisfaction in learning that Frederick William Parham, 1856-1927 (after investigations for him in May 1898 by Rudolph Matas) had already taken up advice to use the Fell method of IPPV, first on 6 August 1898, with the anaesthesia being provided for intrathoracic surgery. The apparatus was later modified by Matas himself, reported in...
1900. First notification of Parham's pioneering use of the Fell–O’Dwyer apparatus for this intrathoracic operation seems to have been in a footnote to an article by Matas, just preceding Parham’s definitive account. Parham was most enthusiastic: “the credit belongs to Dr Fell, of Buffalo, for giving to surgery an apparatus embodying in its practical evolution the principles so ardently urged by Fell and O’Dwyer. As far as I can see I am the first to demonstrate the value of this admirable apparatus ... in maintaining the respiration during operations of this kind” (Footnote 9).

In discussion on Parham’s paper, W E Parker added, “I believe use of the Fell-O’Dwyer apparatus will do a great deal to advancing this line of [thoracic] surgery”.

Fell and his priority rights

Fell’s (possibly smug) attitude to Professor Boehm’s account of FR Patient 2 is already recounted in Footnote 3. When he felt he was not receiving due credit as the innovator of FR, he did not hesitate to write forcefully: for medical pio-

Footnote 9. Chloroform was administered by “the interne” for Parham to remove a large chondrosarcoma extending from the clavicle to the sixth rib. After atmospheric pressure almost completely collapsed the lung, and the patient showed profound shock, “Dr [J D] Bloom was requested to begin the use of the Fell–O’Dwyer apparatus. As soon as the tube was inserted and the apparatus working, the lung began to recover itself, and the man’s condition at once improved. The assistance rendered me ... was so striking that I can without hesitation indorse every word that has been said in its favour. Indeed, so imbued am I with its value that I believe no surgeon now would be justified in attempting thoracic resection without having the Fell–O’Dwyer apparatus to hand. I believe it will revolutionize this field of surgery, making possible operations in the chest that would otherwise be clearly too hazardous to be justified."

Postoperative fevers and abscesses delayed the patient’s successful hospital discharge until 7 November (ie, 4 months).
Whatever happened to Fell?
Before 1895, Fell's publications had been either recapitulating in minute detail, or occasionally summarising, 28-plus cases12A-C in which the Fell method had been used — but not every case he listed or described was one of his own. He produced two further articles before 1900, each including an extraordinary case of opiate poisoning: one patient13 in 1896 needed 73.5 hours of FR (my calculation; Fell says “several long intervals” within a time-span he gives of 83 hours); then another in 1899 needed “over seventy-eight hours”.14[p.170] After these, I can find no other medical publication until 1910.15 Although that 1910 article contains no new FR experience, Fell gives an historical, well-illustrated perspective on his introduction of FR in 1887, and of the validation of his equipment for FR in his early cases. He also places the Fell method (“now termed by some the positive pressure method”16[p.573]) in the context of the other methods of his times for artificial ventilation. One may therefore wonder, did he actually stop his practice of FR in the new century, and, if so, why? From what I have read for this period about Fell, William Mushin and Leslie Rendell-Baker are the only historians to comment. They alone make the particular statement, “Though he retained his interest in microscopy he settled down in Buffalo as an ear, nose and throat surgeon”17.18 His obituary notices17,18 mention illness, culminating in his death in 1918. The brief biographies available are unhelpful for describing these last 6 years.

An obvious inference is that, even after the evidence of the successes he defined so clearly in his case reports, in the face of an unequal struggle to establish acceptance of his method of treatment into wider emergency practice, it all proved too disheartening for him. From 1887–1900, he was undaunted, pugnacious (if not aggressive), critical and even accusatory in his attacks on conventional attitudes to new ideas. His rallying cries for the adoption of FR, and his suggestion it be used for critical conditions other than overdoses, failed against the attitudes and conservatism, “prejudice or ignorance”,14[p.170] of his critics and the sceptics. He had offered a life-saving system; the world had largely ignored it. Perhaps after a dozen years of struggle and example, he just tossed in the medical towel. However, that would hardly accord with either the previous character or the spirit displayed by this man of vision, this pioneer (how many in desperation today would attempt a domiciliary tracheotomy, where that was unavoidable, for a convulsing neonate, just 18 days old, “without proper apparatus”18[p.327]). His record does show continuing consultation in large projects in the engineering world;17 perhaps he just went back to a field where he was better accepted, one perhaps without the jealousies he says he found in medicine. Yet hardly so! Because, as outlined in a brief obituary, this fiery spirit found plenty of opposition to his critical viewpoints concerning engineering controversies in 1903 and 1910.17

After writing the above, I came across Fell’s second 1910 article18 published in a medical journal: seven JAMA pages concerning The currents at the easterly end of Lake Erie and head of Niagara River. Their influence on the sanitation of the city of Buffalo, NY. Fell had delivered the report that year at the American Medical Association Annual Session “in the Section on Preventive Medicine and Public Health.”14[p.828] Again, we can see Fell’s courage and confidence — bolstered by his “former experience as a hydrographic engineer” — in opposing “in toto to the views of the great majority of our healing physicians”.34[p.830] The article concerned the risks of typhoid from epidemic debris brought by “spring freshets” entering Lake Erie, whence the water supply of Buffalo City was drawn. (Again, this was all carried out “at considerable personal expense, which was never reimbursed”.34[p.830]) With his characteristic tenacity, he performed experiments (I cannot find the year) to validate his arguments, confounding his critics. His absence from recording clinical medicine is thus not surprising — and my admiration for his total achievements increases.

To summarise — primitive intensive care medicine
Fell’s activities, especially those of the first dozen years, warrant a valid claim for a pioneering role in ICM. He dealt with critically ill patients, some with severe multisystem disorders. To save their lives when conventional treatments had failed required an extraordinary intervention of skilled personal attention, at times in prolonged application (up to a maximum of around 80 hours of FR was recorded). Fell took on cases of real severity at any hour of the day or night, stayed with his patients until too exhausted to continue, and developed teams to share the burden of hard physical work. He recorded case histories and their features carefully, published repeatedly and was generous in sharing his knowledge and equipment. He was always widening his vision, was desperate to teach his methods to others, and wanted them taught in the curricula of medical colleges. Ultimately, he failed to establish a system of rescue and to have his method widely adopted by professionals and trained paramedics, despite his long striving for its universal uptake.

Fell improved a system used for laboratory animals, adapting it and making it safe for humans. But he also tried to simplify his equipment, with the aim of increasing its application. In the US of his times, he seems to stand alone in finding an effective alternative to inadequate methods of ventilatory support by the then current “artificial respira-
Box 2. Some George Fell aphorisms

In his writings, Fell invoked principles of intensive care medicine that we are familiar with today. Thus:

1888

With suitable apparatus, keeping up the respirations until all the poison could be eliminated.6[p.43]
A physician was not justified in giving up until life became extinct.6[p.49]
The surgeon who manipulates the valve is therefore responsible for any over-distension of the air vesicles.6[p.57]
Forced respiration ... is something more than a dernier ressort compared with artificial respiration.6[p.43]

1889

The only safe rule is to make the attempt [at rescue] because it difficult to state at what stage preceding death it will not prove valuable.7[p.318]
He who would attempt to save human life by forced respiration must be supplied beforehand with suitable apparatus.7[p.417]

1891

Never permit a human life to be sacrificed for want of FR when you can procure a rubber tube ... face-mask ... bellows.9[p.183]
Provision made to exhaust air from the lungs ... complicates the apparatus, and ... is not in accord with physiological conditions9[p.178-9] [and] very dangerous ... in the hand of an average physician in an emergency case.12C[p.123]

1892

In emergencies it is difficult to obtain proper apparatus [which] ... must be supplied beforehand.11[p.131]
... careful attention to the details of practical importance ... not by slipshod methods.10[p.345]
The life of the patient is not out of danger until the poison is eliminated from the system.10[p.346]

1894

Medical opinion must be moulded so that it will be considered hazardous to attempt to save life without proper appliances being provided beforehand.12C[p.126]

tion” from arm–chest manoeuvres. While he saw the need to prevent the unnecessary wastage of human lives from opiate poisoning, he was determined to extend rescue to other, potentially remediable, life-threatening conditions. He foresaw other applications of his principles and methods, including for “tiding over” in critical conditions, such as traumatic shock, asphyxia or near-drowning; and for anaesthesia; and he invoked principles of intensive care medicine that we are familiar with today (Box 2). He advocated readiness of equipment for emergency intervention and action, and then for sustained continuation. It was only later that he came to see that his IPPV method would be useful in neurosurgery, and later again that it could help manage “the pneumothorax problem” of intrathoracic surgery. Others took up Fell’s principles for these problems.

For all Fell’s efforts and attempts to contribute to medical practice and publicise something new and worthwhile, he generally met a stonewall of resistance from the ranks of conservative medicine. Fell, however irascible and “prickly”, deserves to be remembered with admiration for his sterling efforts and his successes. His plea for recognition of his priority right for utilising IPPV in saving lives is warranted. It bears repeating that a medical obituary could claim, “He gave his [FR] discovery to the cause of humanity and has made nothing from his work”. 17

Surely he merits a cognomen of “Primitive Intensivist”?

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Appendix 1. Some individual case histories of forced respiration (FR)*

1: Showed that FR can inflate lungs to “save a life”, without causing damage to the lungs. Peritracheal ligation.

3: (Fell’s second FR patient). After artificial respiration had failed for a “difficult” case and even when Fell delayed FR to a late stage, and was “urged to discontinue” as the patient was “considered hopeless”. FR prolonged for 14.5 hours was successful — “accomplished only through the new apparatus [Fell] had specially devised for use upon human beings”. The patient was very seriously ill for the next 3–4 days. Fell was already seeing indications for FR with the drowned.

4: With employment of a team (students and physicians) to supply FR for 24 hours with recovery, after the patient was first “already given up … to all appearances dead (so reported)“, and a coffin delivered. “A physician was not justified in giving up until life became extinct.” (The patient had provided his own [suicidal] entrance wound for the tracheotomy tube.) Fell claimed the saving of three lives (nos. 1, 3 and 4) saved insurance companies $23,000 in life policies.

5: FR for longer than 14 hours failed save an 80-year-old who had taken an opiate overdose (Fell was called to him at the local hospital).

6: FR per tracheotomy failed because of 4½ hours’ delay in calling for Fell’s assistance to an infant aged 18 days after a massive morphine overdose (1 gram = 64.8 mg; circa 70× overdosage) or even 80× per ½ inch (external) catheter, via a tracheotomy (and an increasing series of larger tubes back to the air valve) was called “hard work” for 3½ hours. Death from misadventure (caused by another).

7: FR per tracheotomy for a man (hospitalised) with opium “spasmodic respiration”, whose return of wrist pulses lasted only an hour before he suffered cardiac “final stoppage”. Fell: “I waited too long.”

* I have retained Fell’s enumeration system for the FR cases in his publications, because his numbering included some FR patients who were not his own. To exclude these would produce confusion with numbering “his” patients. The best general reference for the numbered patients is Fell’s own 1894 report in the Canada Medical Record,12 supplemented by his reports in the Transactions of the New York State Medical Association9 and the Archives of Pediatrics.10
Appendix 2. Some individual case histories of forced respiration (continued)

8: This case showed that FR without tracheotomy is possible, by using mouth-to-mouth inflation. FR supplied through a tube sealed off within the mouth of a stillborn (forceps delivery, “ruptured brain”: a hopeless case), abandoned after 4–5 hours. The case indicated the need for “a suitable mouth-piece”.

9: “Dying” opiated patient, with dilated pupils of asphyxia, received successful preliminary FR inflation per a mouth tube, then tracheotomy and FR for 11 hours with survival.

10: The same patient again, heavily opiated (2fl. oz. tinct. Opii [591.5 mg morphine] + 5–10 grains morphine [324–648 mg]); tracheotomy for FR of 14 hours, recovered. Patient certified. Note: Regular FR for Cases 9 (11 hours), 10 (14 hours) and 11 (4 hours) was a success, while the patient in Cases 9 and 10 led to “preparation of the face mask” covering mouth and nostrils, providing new options.

15: Morphone overdose; face mask proved superior to artificial respiration, 9 hours’ successful FR, but the patient died after a colleague’s interfering faradisation attempts. So death by misadventure, another’s mistake. “I do not as yet recommend intubation”. Fell predicted using FR for more than poisoning. 8

17: Morphine overdose, 15 grains (=972 mg); after 3 hours of face mask-FR, the woman’s state deteriorated to absent heart sounds, so, at tracheotomy she was considered as being of “no hope”; but better FR (which was “evident”) enabled recovery after 12–14 hours total of FR.

18: With FR by face mask (10.5 hours); ligature needed for the obstructing tongue; serious gaseous distension of stomach and bowels; anuria; Fell’s first extended use of oxygen; then tracheotomy. But after FR totalling 18 hours’ work, patient vomited, aspirated the vomitus, and died. Fell recommended “something other than manual labour” for the amount of energy expended for FR.

19: Wrongly dispensed corrosive sublimate swallowed by a 73-year-old; face mask-FR enabled her to live 2 days, but death by misadventure, another’s mistake. An “excess amount of energy expended in respiring for a human being” indicated the need for mechanical aid.

21: A woman aged 78 years with opium narcosis received FR for 11 hours per face mask; ligature needed through tongue, then tracheotomy, but suffered status convulsions, and died. Fell recognised his error of judgement in waiting too long before intervening with a tracheotomy.

22: Took morphine, 11 grains; Cheyne–Stokes breathing, almost in asystole before Fell arrived; FR by face mask for 4 hours was successful.

23: A prisoner with opium overdose had FR by face mask but was cyanosed for 30 minutes; recovered after 4 hours. Venesection. Died unexpectedly a few days later, of heart failure. Fell said: “intense congestion of the encephalic vessels”.

24: Laudanum overdose. Doctors at Fitch Hospital declared “no hope” after 5½ hours of artificial respiration; the patient’s wife demanded Fell attend, so FR, and patient recovered; but stupor recurred for days at home due to a stove leaking natural gas; patient recovered rapidly when shifted. Fell insisted hospitals maintain their own equipment to treat by FR.

25: (1892, when “19 human lives have been saved by this [FR] method”), 11b[.130] When two general practitioners could not use the FR apparatus on a man, “reported as hopeless” after morphine overdose, the ill Fell’s student nephew did so successfully. 11b[.130]

26: Subcutaneous morphine, total 3½ grain (43.2 mg) for a woman’s colic. Cyanotic, so artificial respiration for 5½ hours, but cyanosis was so profound that Fell and GP thought she would die before a tracheotomy. Recovered after 5¼ hours’ FR.

27: Malnourished woman, opium poisoning, with respiratory rate of 3–4 per minute and cyanosis. Fell was unavailable, so “for ten mortal hours we used [his apparatus] continuously” (or occasionally), with recovery. 12b[.99]

28: 7-year-old boy with dipthheria and life “in immediate danger” (dilating pupils). Tracheotomy, then FR on six to seven occasions, but tenacious membranous casts of tubes and trachea. Died after 2 days, of “exhaustion and heart failure”.

29–44: 16 patients of the Fitch Accident Hospital, 12b of whom Fell lists: 7 poisoned with opium, 3 with cocaine, 1 with “carbonic oxide” (CO), 1 with rat poison, 1 with ether narcosis, 2 with trauma, 1 drowned and 1 unspecified. Very brief notes on treatment are presented by Drs John Paramenter and E L Ruffner. There were 9 survivors; the 7 deaths were from opium (3: 2 from long lying, and 1 from heart failure), drowning, brain injury, uraemia (after CO), pneumonia (“injury from house falling on him”). 12b[.101]

Unnumbered anaesthesia cases: with a need for FR after the agents ether, chloroform or nitrous oxide. 13

Unnumbered: The remarkable 1896 case of Dr Henry J Williams. The method’s most severe test, where, since “the case was so desperate” from multi-agent opiate overdose, a tracheotomy tube quickly replaced the initial face mask for “the necessary factor in the life of the patient”, and oxygen was also supplied. For the three cycles of FR needed “the apparatus was in constant use”, during 73.5 (of 87) often stormy hours. 15b[.576] There were multiple alarms from failure of Fell’s repeated efforts during that time to re-establish reliable spontaneous breathing. The treating team comprised more than 20 named physicians, plus medical students. FR “speaks volumes for the perfect working of the simple apparatus”.

Unnumbered: The remarkable 1898 case of Raymond Archer. 14 At first, he was gasping at the rate of 1 breath per minute, cyanosed, almost pulseless, after 33 grains morphine. Archer survived “over” 78 hours 14p[,170] of FR at his home: first per a face mask for 2 hours, then per tracheotomy. Archer’s was another case where during “a tonic convolution” the tracheal ring failed to prevent aspiration, mainly of water that had been placed in the stomach, but without disaster following.