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Operative vaginal delivery – An historical perspective

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A B S T R A C T

This chapter will cover the evolution of forceps and vacuum-assisted delivery of the foetus in cephalic presentation. The options available before the development of obstetric forceps are briefly reviewed. The invention of the forceps in the early 17th century was followed by their evolution over four centuries with the introduction of the pelvic curve, axis-traction and rotational forceps. The phase of prophylactic forceps delivery will be discussed. The development of vacuum-assisted delivery has evolved over the past 150 years. However, in practical terms, the modern era of vacuum-assisted delivery began with Tage Malmström's vacuum extractor in the early 1950s. The evolution of the modern vacuum extractor with metal, soft and hard plastic cups will be reviewed.

Until the development of obstetric forceps in the early 17th century, the only instruments available to assist delivery of the foetus with obstructed labour were mostly of the destructive variety. Two of the more commonly used instruments were the fillet and the vectis. The fillet was a loop that was placed around the head, usually beneath the occiput, to provide traction. The loop could be soft (silk, cotton or leather) or firm (cane, whalebone or wire). Their use began in the Hippocratic era and continued into the 19th century. The vectis or lever was made of bone, ivory or metal and was rather like one blade of the obstetric forceps. The vectis was used as a lever to ease the head down, with the pubic arch acting

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as the fulcrum, or to correct malposition by flexing the foetal head to assist descent from higher in the pelvis. The fillet and vectis might deliver a live infant, albeit with at least superficial injuries. If these relatively atraumatic instruments failed, the remaining option was the use of destructive instruments, such as perforating scissors, crochet (sharp hook), blunt traction hook and the crushing cephalotribe or cranioclast – all aimed at delivering the foetus in piecemeal fashion. The details of use of these destructive instruments are beyond the scope of this chapter, and the interested reader is referred to the works of Radcliffe and Hibbard [1,2].

Although there has been debate about the possible use of obstetric forceps to deliver an intact infant in ancient times, the consensus is that this was not the case and that the forceps described were of the crushing destructive type [2–4].

With very rare exceptions, caesarean section was only undertaken as postmortem; mostly to satisfy religious edicts and in the vain hope of rescuing a live infant. It was not until the late 19th century that caesarean delivery became a realistic alternative to instrumental vaginal delivery in selected cases [5].

Before the 17th century, the main involvement of the male surgeon-accoucheur in the birth chamber was when the midwife called them to use destructive instruments to deliver the foetus in an obstructed labour. The emphasis for the male accoucheur was to save the mother, as the baby was usually dead by the time they were called to assist. Thus, the presence of a doctor usually heralded a disastrous outcome for the infant and often for the mother as well.

Forceps-assisted delivery

> *'It requires the greatest judgment in laborious cases when the head presents to distinguish how long to wait, and when to assist, as well as after what manner …. When there is no immediate danger either to the mother or child, it is better to wait, till the head is squeezed lower in the pelvis, and when there is the least appearance of danger, you can then safely deliver with the forceps.'*
>
> William Smellie, letter to a pupil, 1749 [1].

Central to the development of the clinical art of obstetrics is the invention and evolution of the obstetric forceps – one of the few surgical instruments that have remained in use for four centuries. To a large extent, it was the availability of forceps that expanded the participation of physicians in the labour room and led to the specialist man-midwife.

Introduction of the forceps

The obstetric forceps were invented by the son of an immigrant French Huguenot fleeing religious persecution in France. William Chamberlen (d. 1596) was a surgeon in Paris who arrived in Southampton, England, in 1569 – later moving his family to London. A hallmark of the Chamberlen family was a singular lack of imagination in their choice of Christian names. William named two of his sons as Peter – known as Peter the Elder (d.1631) and Peter the Younger (1572–1626) – both barber-surgeons. Peter the Younger also had a son named Peter, who qualified as a physician and became known as Dr Peter (1601–1683). He had a son, Hugh Senior (1630–1720), who in turn had a son, Hugh Junior (1664–1728). Over four generations, all these Peters and Hughs practiced obstetrics. It is probable that Peter the Elder devised the forceps, followed by improvements from other family members over the years. The main features were fenestrated blades with a cephalic curve, and flattened shanks to provide a cross-over pivotal joint with holes to accept a securing pin [6–8]. In an era when perceived female modesty dictated that male accoucheurs worked under a sheet, the Chamberlens were able to keep the 'secret instrument' to themselves for more than a century.

In the early 1700s, two other English obstetricians published texts that included illustrations of obstetric forceps with similar features to those of the Chamberlens. In his book of 225 case reports, William Giffard (d. 1731), recorded his successful use of forceps on 28 June 1728, 'This case proves, that a child presenting right, but sticking in the passage, may be brought alive (I won't say always) without

either use of hooks, or lessening the head, contrary to the opinion of most former writers.' [9] He had the honesty to note that he had tried the forceps unsuccessfully in a previous case on 18 April 1726. Edmund Chapman (1680–1756), of Essex and London, was the first to write extensively on the subject of obstetric forceps, and he also provided illustrations and specifications. He wrote of the forceps in glowing terms, 'All I can say in praise of this noble instrument must necessarily fall short of what it justly demands' [10].

Jan Palfyn (1650–1730) of Ghent, a barber-surgeon and anatomist, wrote of the unsatisfactory nature of destructive instruments [11]. He conceived the idea of an instrument that would grip the foetal head like a pair of hands – *mains de fer* as he called them. He presented these before the Royal Academy of Sciences in Paris in 1720. The blades had a cephalic curve but no overlap or locking mechanism. They were inserted separately alongside the foetal head and held in each hand, rather like salad spoons. As such, they slipped off the foetal head with minimal traction, even when the handles were tied together.

The pelvic curve

Independently, three obstetricians introduced the pelvic curve to the forceps, which made the instrument more suitable for application to the foetal head higher in the pelvis [12]. Andre Levret (1703–1780) presented this feature to the Paris Academy of Sciences in 1747 [13]. Benjamin Pugh (1715–1789), a man-midwife from Chelmsford, England, wrote in the preface of his 1754 text, *A Treatise of Midwifery,* 'The curved forceps I invented upwards of 14 years ago.' [14] William Smellie (1697–1763) of Lanark, Scotland, devised both short straight forceps and longer forceps with a pelvic curve for use higher in the pelvis and for delivery of the after-coming head of the breech [15]. Smellie also improved the locking mechanism for the shanks, which became known as the English lock and remains a feature of the modern forceps.

While the pelvic curve gave the man-midwife the ability to grasp the foetal head higher in the pelvis, it also allowed more trauma to be applied to both the foetus and the mother. It was Smellie, the greatest obstetrician of his era, who emphasised that the forceps should be applied cephalically, ' …. over the ears of the child.' The less skilled obstetrician applied the forceps blades in the plane of the pelvis, without reference to the position of the foetal head – often resulting in severe trauma to the foetal face. Smellie also urged caution in their use, 'Only ten out of one thousand labours require instrumental delivery.' William Hunter (1718–1783), a pupil of Smellie, was aware of the damage forceps could do in the wrong hands ' …. the forceps (midwifery instruments in general I fear) upon the whole, has done more harm than good' [12].

During the last half of the 18th century, in large part due to their access to forceps, the male surgeon-midwife began to encroach upon the previously all-female domain of the midwifery [16].

Axis traction

It was soon apparent with forceps delivery from the high and mid pelvis that much of the traction force was misdirected against the anterior pelvic wall. This was both inefficient, necessitating more force than necessary to deliver the foetal head, and also traumatic to the maternal soft tissues which were compressed against the bony pelvis – particularly the bladder.

Some of the early obstetricians, including Levret and Smellie, taught that the line of traction should be as posterior as possible. The classic technique to achieve this, downward pressure on the shanks with one hand and traction on the handle with the other, is attributed to Charles Pajot (1816–1896) of Paris and is known as Pajot's manoeuvre [17]. It had in fact been clearly described by Matthias Saxtorph (1740–1800) of Denmark a century earlier [18].

Many forceps were designed with a sigmoid curve to the shanks and handles in order to pass up and over the perineum and bring the point of traction from the lowered handles more in line with the axis of the pelvis [2]. The use of tapes placed through the fenestrae of the forceps blades to provide downward traction was also suggested by Saxtorph and used in many forceps designed up to the 20th century [19].

It was Stéphane Tarnier (1828–1897) of Paris who studied the mechanics of pelvic traction in great detail and devised a practical set of axis-traction forceps in 1877 [20]. He employed two craftsmen and tried approximately 30 different models before he accepted one with two slim rods, fixed by articulating joints to the blades just below the fenestrae. The rods were attached to a separate handle below the forceps, and traction on this was in the axis of the upper pelvis, resulting in much less force to achieve delivery. Others, notably Milne Murray (1855–1904) of Edinburgh, designed lighter versions [21]. In 1866, William Neville (1855–1904) of Dublin produced his axis-traction handle, which was a simple device that could be attached to conventional forceps [22]. It was easier to use than axis-traction forceps and, being attached to the handle of the forceps it did not distend the perineum, in contrast to the traction rods of the forceps. Originally designed for use with Barnes long forceps, it was widely used and known as the Barnes-Neville forceps. Tarnier's forceps or modification thereof were considered a major advance, reducing by up to 50% the traction force required for delivery. They were used until the mid 20th century when high and difficult mid forceps were abandoned.

Forceps rotation of the foetal head

Christian Kielland (1891–1941), the Norwegian obstetrician from Oslo, designed straight forceps in 1910 with only a slight pelvic curve to deliver the malrotated foetus, occipito-transverse or occipito-posterior, from the mid and upper pelvis [23]. These forceps allowed accurate placement along the foetal biparietal diameter. Kielland included a sliding lock to allow correction of the asynclitism that is common in these malpositions. He laid down strict and precise instructions for the use of his forceps which, when followed, produced good results in the era of high and mid forceps. In 1928, Lyman Barton (1866–1944), a rural general practitioner in New York State, developed straight forceps with a hinged anterior blade to facilitate its application to the foetal head in the transverse position at the pelvic brim [24].

In the 'nothing new under the sun' category, William Smellie approximately 150 years earlier had used his long forceps to rotate and deliver the foetal head arrested in the occipito-posterior position: 'I luckily thought of trying to raise the head with the forceps, and turn the forehead to the left side of the brim of the pelvis, where it was widest, an expedient which I immediately executed with greater ease than I expected. I then brought down the vertex to the right ischium, turned it below the pubes, and the forehead into the hollow of the sacrum, and safely delivered the head …. .This method succeeding so well, gave me great joy' [25].

By the late 20th and early 21st century the use of rotational forceps had dwindled to a small number of committed and experienced obstetricians.

Classical forceps

Other than specialist forceps providing axis-traction or rotation, the most commonly used type of forceps from the late 19th century were the so-called classical forceps, with the cephalic curve relating to the foetal head and the pelvic curve to the maternal pelvis [26]. The more popular of these forceps included Simpson's, Haig Ferguson's, Barnes-Neville (without the traction handle), Elliot's and Tucker-McLane forceps, which had solid blades [12,19,27]. Some of these forceps, such as Simpson's forceps had short and long versions – depending on the level of the pelvis at which intervention was planned [27]. In 1935, Joe Wrigley (1902–1983) of St Thomas' Hospital, London, spoke against assisted delivery in the high or mid pelvis and advocated only low forceps. He designed his own short forceps for this purpose – based on Smellie's original short straight forceps, but with an added pelvic curve [28]. Wrigley's forceps enjoyed popularity in the latter part of the 20th century.

In 1929, Kedarnath Das (1867–1936), professor of obstetrics in Calcutta, published his classic work on obstetric forceps [4]. After 12 years of research and going through approximately 2000 references, he identified more than 550 varieties of forceps. In the 19th century, it seemed that any obstetrician of note, and some of little note, designed their own forceps seeking eponymous fame. Each country, hospital and accoucheur had their own favourite forceps, often influenced by a prominent obstetrician in their region.

Vacuum-assisted delivery

Compared to forceps, use of the vacuum extractor has a much shorter history. The first recorded attempt to assist delivery using the vacuum principle was in 1705 by James Yonge (1647–1721), surgeon to the Naval Hospital in Plymouth, England. Faced with a foetal head ' …. stuck immovable at the os pubis …. ,' he attempted ' …. to draw it out by a cupping-glass fixed to the scalp with an air pump' [29]. The procedure failed, and he was forced to use destructive instruments to deliver the baby.

More than 100 years later, Neill Arnott (1788–1874), a Scottish physician working in London, outlined the principles of a pneumatic tractor [30]. There is no record of him ever using this instrument, but he did suggest, rather disdainfully, that it might have an obstetric role: 'Now it seems peculiarly adapted to the purpose of obstetric surgery, viz, as a substitute for the steel forceps, in the hands of men who are deficient in manual dexterity, whether from inexperience or natural inaptitude.' Arnott argued that competence with forceps delivery required long and continued experience, and that use of the pneumatic tractor would require less skill and training. A sentiment that was echoed by some in the last half of the 20th century, to the detriment of safe vacuum-assisted delivery.

In 1849, James Young Simpson (1811–1870) of Edinburgh, who acknowledged the work of Arnott, developed his practical 'suction-tractor' and used it with success in a number of cases. It was to be the forerunner of the modern vacuum extractor developed a century later. He did however state: 'I believe that the construction of the air tractor is still very far from being so perfect as it will yet be rendered' [31].

Simpson did not write further on vacuum extraction. A year earlier he had introduced his obstetric forceps; they were to become the most popular of the classical forceps and remain in widespread use 150 years later [12,26,27]. Over the next century, many individuals developed a variety of vacuum extractor devices – with limited success: in Argentina, Alberto Cladish (1933); in France, Soubhy Saleh (1857) and Yves Couzigou (1947); in Germany, D Kuntzsch (1912) and P Körber (1952); in Japan, T Hasegawa and R Shiojima (1951); in Norway, O Koller (1950); in the United States, Herbert Stillman (1865), Peter McCahey (1890) and Richard Torpin (1938) and Victor Finderle (1952) in Yugoslavia [32–41].

Among these early innovators, Peter McCahey of Philadelphia was the first to point out the importance of flexion of the foetal head in vacuum-assisted delivery: 'The large amount of force apparently required in some cases is because it is misdirected. The head is not properly flexed, and traction is exerted in a direction that would tend to pull the occiput through the pubic symphysis, instead of under the pubic arch …. ' [34] Others, including Koller and Torpin, used the vacuum with light continuous traction before full cervical dilatation in cases of poor uterine action. Before the use of oxytocin augmentation, this could have the same effect by activating the release of endogenous oxytocin through Ferguson's reflex [12,26].

The modern era of vacuum extraction began in 1953, and its architect was Tage Malmström (1911–1995) of Gothenburg, Sweden. The most important component of his design was the metal cup with an in-curved rounded margin [42,43]. Thus, the cup margin attached to the foetal scalp was of a narrower diameter than the upper margin, which produced a 'chignon.' This effectively increased the total surface area of scalp application, thereby reducing the risk of cup detachment during traction. Malmström originally used his vacuum extractor with continuous traction before full cervical dilatation to enhance uterine contractions [42,43]. He refined his instrument between 1953 and 57, and, as its role developed, the vacuum extractor came to be used as an alternative to forceps delivery. In the Malmström cup, the suction and traction components were attached through one port in the top centre of the cup.

The next major development came from Geoffrey Bird (1922–2001), an English obstetrician who worked in Kenya, Papua New Guinea and Australia [12,44]. Bird emphasised the need to place the cup over the flexion point in the median position to promote flexion of, and therefore, the narrowest diameter of the foetal head [45]. To facilitate this, he separated the suction and traction portals, moving the suction port to the side of the cup, which allowed placement over the flexion point, 3 cm in front of the posterior fontanelle. This extra manoeuvrability of the cup was essential in deflexed occipito-posterior positions. The other modification made by Bird was to indent the top of the cup, which brought the traction point closer to the foetal scalp. The Bird 'OP' cup was originally made in the

workshop of the King Edward Memorial Hospital in Perth, Australia, where he worked at the time. Geoffrey Bird also taught that traction was a two-handed exercise: 'The thumb of the non-pulling hand, pressed firmly against the cup near the rim, helps to prevent the cup from tilting off the scalp. The index finger of the non-pulling hand, resting on the shoulders of the cup with its tip touching the scalp, monitors descent.' [12] The index finger was used to detect descent of the scalp without descent of the bony skull - negative traction as Bird called it, and a sign of unyielding obstruction. Bird's modification of the Malmström cup, the emphasis on correct placement over the flexion point, and his advice on the finger-thumb traction technique remain the basis of best practice in vacuum-assisted delivery.

By the 1970s, the Malmström vacuum extractor had gained wide acceptance in Africa, Asia, Europe and Scandinavia. In some units, it completely replaced the forceps [33]. Its advantages, compared to forceps, included less maternal trauma and the ability to perform it under local anaesthesia. In North America, however, it did not achieve much popularity, probably due to a combination of the unsightly chignon and growing obstetric litigation.

In 1973, in an attempt to reduce scalp trauma, Dr Kobayashi, professor of obstetrics at Tokyo Medical School, produced a 65 mm bell-shaped soft silastic cup attached to an electric pump [46,47]. The Swedish manufacturers of the Malmström and Bird instruments produced a European version, named the Silc cup [48]. A number of bell and trumpet-shaped cups made of silastic or soft plastic became available in the 1970s and 1980s [49,50]. Some of these had creative if unsubstantiated names, such as Soft-touch and Tender-touch [50]. The soft cups did result in less superficial scalp trauma and a less pronounced chignon, but no reduction in the rare cases of intracranial trauma. Their main drawback turned out to be a higher failure-to-deliver rate compared with metal cups.

By the late 1990s, there was increasing disenchantment with this high failure rate, up to 25% with soft cups compared to 2–4% with metal cups [33,50]. Aldo Vacca (1941–2014) the Brisbane obstetrician, who trained with Bird in Papua New Guinea, felt that the soft cup bell-shaped design was inappropriate for placement over the flexion point in the deflexed occiptio-transverse and occipito-posterior malpositions [51]. He advocated a return to the design principles of the Malmström and Bird vacuum cups. One company, Clinical Innovations of Utah, heeded his advice and, under his guidance, developed a 5 cm hard plastic cup with the traction and suction portal in a recessed groove on the top of the cup. Attached to a small palm-compression vacuum pump, the relatively flat cup could easily be manoeuvred over the flexion point; it was named the OmniCup [50,52]. Since its introduction in 1999, the OmniCup has been used extensively throughout the world [53].

The latest entrant into the field of vacuum-assisted delivery was conceived by Jorge Odón, a car mechanic from Argentina. He saw a demonstration of a technique to remove a loose cork in a wine bottle through a plastic bag inserted into the bottle, manipulated around the cork, inflated and then withdrawn with the cork. Odón thought the principle could be applied to delivery of the foetal head and talked to an obstetrician who encouraged him to develop the idea. Using a sleeve stitched over a cloth bag Odón tested his concept with a doll and a glass jar. The device has been manufactured, and the World Health Organization has set up the Odón Device Research Group to study its feasibility and safety [54]. The hope is that it may provide a simple, low-cost alternative for low-resource settings. A pilot study has been carried out with promising results [55]. Apart from the cunning double layer sleeve approach, the device has some precedent in the Elliot bonnet of the 1990s [49,56].

Historical trends in assisted vaginal delivery

As obstetrical forceps became available in the 1700s; they were used mainly as an alternative to destructive instruments in cases of cephalo-pelvic disproportion, provided the pelvis was not so distorted as to preclude their application. They could also save the mother from the soft-tissue damage and the inhumanity of a prolonged second stage of labour – sometimes measured in days rather than hours [5,12]. Unfortunately, some obstetricians used forceps to excess and without skill, leading to foetal damage and criticism from midwives [57].

However, the standard teaching of the time, exemplified by the respected London obstetrician Thomas Denman (1733–1815), was very conservative. One of Denman's Laws stated that the foetal head should have ' …. rested for six hours as low as the perineum, that is, in a situation which would allow their application, before the forceps are applied … ' [12,58] Denman's son-in-law and pupil,

Richard Croft, became obstetrician to Princess Charlotte, third in line to the throne of England. In 1817, Croft allowed the princess to remain in the second stage of labour for more than 24 h, without using forceps to assist her delivery. She died following delivery of her stillborn infant. Richard Croft later committed suicide in disgrace and despair [59]. As a result, the royal lineage was disrupted, which led to the reign of Queen Victoria.

At the other extreme, approximately 100 years later, Joseph DeLee (1869–1942) of Chicago, ushered in an era of 'prophylactic forceps.' DeLee regarded labour as a pathological process, with the second stage of labour causing damage to the maternal soft tissues, resulting in fistulae, laceration and prolapse. The foetal brain, he felt, could be damaged by the sustained pressure against the bony pelvis. His answer to this potential pathology was ether anaesthesia in the second stage of labour, forceps delivery with a wide medio-lateral episiotomy and manual removal of the placenta [60]. DeLee's stature in American obstetrics was such that he influenced a generation to follow his lead, thus resulting in forceps delivery rates exceeding 50% in some hospitals.

By the 1950s and 1960s, a number of factors reduced the forceps delivery rate. Caesarean delivery became safer for the mother, and this led to the abandonment of high forceps and the risks it posed to the baby [5]. Oxytocin augmentation, foetal heart rate monitoring and regional anaesthesia allowed the safer and more humane management of non-progressive labour – reducing the need for intervention [61].

Mid forceps delivery came under critical scrutiny in a 1953 article by the American obstetrician, Stewart Taylor of Denver, Colorado, entitled 'Can mid forceps operations be eliminated?' He defined mid pelvic arrest at the level of the ischial spines. This occurred in one in 324 deliveries at his hospital, with a foetal mortality of 26% - results that would have supported an affirmative answer to the question posed [62]. Friedman and others argued that mid forceps was associated with unacceptable risks to the baby, and by the 1990s it had become an infrequent choice for delivery [63,64].

From the late 20th century to the present, the assisted vaginal delivery rate has varied between 5 and 15% in most countries [65]. There are wide variations between different hospitals and regions. Within hospitals, there can be considerable differences between individual obstetricians. Over the past 30 years, there has been a shift from forceps toward vacuum [65,66]. Thus, in the modern era, assisted vaginal delivery is usually from the low pelvis and is more likely by vacuum rather than by forceps. The main debate now is about long-term pelvic floor dysfunction in the mother and not the potential damage to the infant.

Conflicts of interest

None.

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