



The Evolution of Orthotopic Bladder Substitution: Faults and Fixes

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Abstract

Background: Much more patients qualify for Orthotopic Bladder Substitution (OBS) than actually get it. One major reason is the unguaranteed continence outcome.

Objective: Understanding the evolution of OBS and to analyze faults why these process spans 100 years from the idea of Tizzoni and Foggi in 1888 to a standard surgical procedure with acceptable continence.

Design, Setting, and Participants: The author's comprehensive OBS registry was reviewed. For the first part of the analysis from 1888 till 1987 any report on OBS has been analyzed, later only sizable series that stood the test of time.

Results and Limitations: The faults of Tizzoni and Foggi published promising preliminary results and withheld disastrous long-term outcomes. Their excellent results must be attributed to the regenerated bladder rather, than bladder substitution. The tubular segment then became a diverticulum. Two negative consequences resulted. First, for 100 years surgeons have repeated the faulty set up of a tubular reservoir. Secondly, numerous patients were rendered incontinent. Detubularization and cross-folding of the ileum were published in 1899 and 1953, respectively; however, they had gone unrecognized until 1987.

Conclusion: Since the 18th century the goal of urinary diversion has been to replace bladders. The evolution of OBS demonstrated a discrepancy between surgical ambition and disappointing continence outcomes. A sloppy literature search and faulty experimental setup have resulted in imperfect techniques. Techniques including perfect detubularization and cross folding provide reproducible continence results and have stood the test of time. Recently unsatisfactory reservoirs are increasingly used to speed up the operation. It is important that we learn from the past and not make the same mistakes in the future.

Patient Summary: Following removal of the bladder urinary diversion is required. The standard incontinent diversion with stoma and bag as well as OBS uses a gut segment. The complicated evolution of the neobladder is presented.

Keywords: Urinary diversion; Orthotopic reconstruction; Evolution; Detubularization; Cross folding

Introduction

A satisfactory Orthotopic Bladder Substitute (OBS) must allow complete voluntary control of voiding, urinary continence and a normal micturition pattern in a physiological posture. This can be guaranteed by using an OBS. Furthermore, Bricker's statement from 1950 "Urinary continence must not be achieved to the detriment of renal function" remains valid [1]. From the idea of OBS in 1888 till these requirements were fulfilled by the surgical technique exactly 100 years had elapsed (Figure 1). In 2022 up to 80% of men and 65% of women undergoing Radical Cystectomy (RC) are candidates for OBS [2]. However, population based data show that 90% of patients in the US and 60% in Germany instead get conduit Urinary Diversion (UD) [3]. In contrast at select centers of excellence around the world, the majority of patients undergo OBS. Why the disparity? Many urologists performing RC lack sufficient experience to offer OBS or believe that there are higher complication rates with OBS, a perception that is challenged by centers with experience [2].

This study analyzed 100 years of errors and negative developments that dramatically delayed the evolution of OBS and led to numerous imperfect OBSs in patients worldwide.

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Materials and Methods

This study was based on a manual search of the literature. Over more than 50 years the author prospectively collected more than 700 articles on OBS. Highlights of the retrospective part of the search process (1888-1980) were visits to the libraries in Bologna where Europe's first university was founded in 1088 and Florence. Without the support of Professor Mantorana, MD, in 2006 Chairman of the Department of Urology at Bologna, where Tizzoni and Foggi did their groundbreaking work, access to original articles would have been impossible. With two exceptions no studies limited by small cohort sizes have been used for this analysis [4,5]. Only sizable series (>50 patients) that stood the test of time (>15 years of follow up) with confirmed results by at least one other institution were considered for evaluation of the final technique.

Results

The idea

The first milestone in OBS was the replacement of the urinary bladder. In 1888, Tizzoni and Foggi in an animal experiment in a healthy dog substituted the bladder with a tubular ileal segment by anastomosing its distal end to the bladder (neck), while closing the proximal end and implanting the ureters laterally into the ileal segment [6]. Development of perfect continence within <2 months after surgery prompted the authors to submit an enthusiastic report without further follow up [6]. However, major faults had occurred (Figure 2). Apart from the ultra short follow-up there was no histopathological confirmation of the results. It went unnoticed that the functional integration of the ileal segment had failed, and it became a diverticular structure at the top of a completely regenerated bladder (Figure 3). The promised follow up in the "Centralblatt Für Chirurgie", the leading surgical journal of that time, never appeared. The truth was published in 1891 in local university journals in Bologna and Florence [7,8]. These articles remained unnoticed until 1925 when Ravasini [9] reported the disappointing results. The experimental design of Tizzoni and Foggi can be followed as a recurrent principle by Couvelaire [10] (Figure 4a), Cibert [11], Pyrah [12] (Figure 4b), Lilien and Camey [13] and many others. They all reported long-term results in a large series of patients with Bladder Cancer (BC), but continued to use a tubularileal loop anastomosed to an incompletely resected prostatic urethra. The disappointing continence results were not caused by the insufficient competence of

the sphincter mechanism, but because the tubular intestinal reservoir maintained its peristaltic properties, causing high pressure peaks.

A comparison of outcomes with regard to continence and intrareservoir pressure is not meaningful. There is a nonlinear relationship between the gut length and reservoir volume. Small changes in length have considerable effects on the reservoir capacity and pressure. Authors use extremely variable ileal segments lengths for the reservoir construction of 6 cm (Rutkowsky) [14], 15 cm (Giertz) [15], 30 cm (Couvelaire) [10], 40 cm (Kock) [16] till 60 cm (Pyrah) [12].

Detubularization

Detubularization of bowel segments is the second milestone in the evolution of OBS. In the literature, credit for this goes to Kock [16]. In 1969 he published his "preliminary observation on a procedure resulting in fecal continence in five ileostomy patients". The goal was, to provide patients with a permanent ileostomy with the possibility of voluntary control over intestinal emptying, and for that purpose he decided to create an intestinal reservoir in patients with a permanent ileostomy. In 1969 Kock [16] constructed an ileal bladder substitute after subtotal cystectomy to test the continent reservoir hypothesis (Figure 5a). The construction was based on the principle of fixed direction of peristaltic movement in the gut. By splitting the intestine at its anti-mesenteric border and folding the split intestine twice, the motor activity in different parts of the bladder substitute counteracts itself. This information was recorded cystometrographically. After obtaining satisfactory results with this intestinal reservoir as an OBS, he decided to use it in patients with permanent ileostomies. A previous publication using the identical technique for OBS construction neighbor and countrymen, the urologists Giertz and Franksson [15,16] describing the "construction of an ileal substitute bladder with preservation of the urethral voiding, after subtotal and total cystectomy" in 1957 had gone completely unrecognized and unreferenced (Figure 5b). Giertz [15] however, was fair enough to reference those researchers from whom he got the idea of detubularization and cross folding an ileal bladder substitute to the prostatic urethra. He concluded that no more than half of the prostate could be removed. The reason for this requirement was that his reservoir was constructed just from 15 cm of ileum. He got the idea of lowering the reservoir pressure from Rutkowsky [14], who in 1899 referenced and improved the experimental setup of Tizzoni and Foggi [6] by using for the first time, a detubularized gut to expand

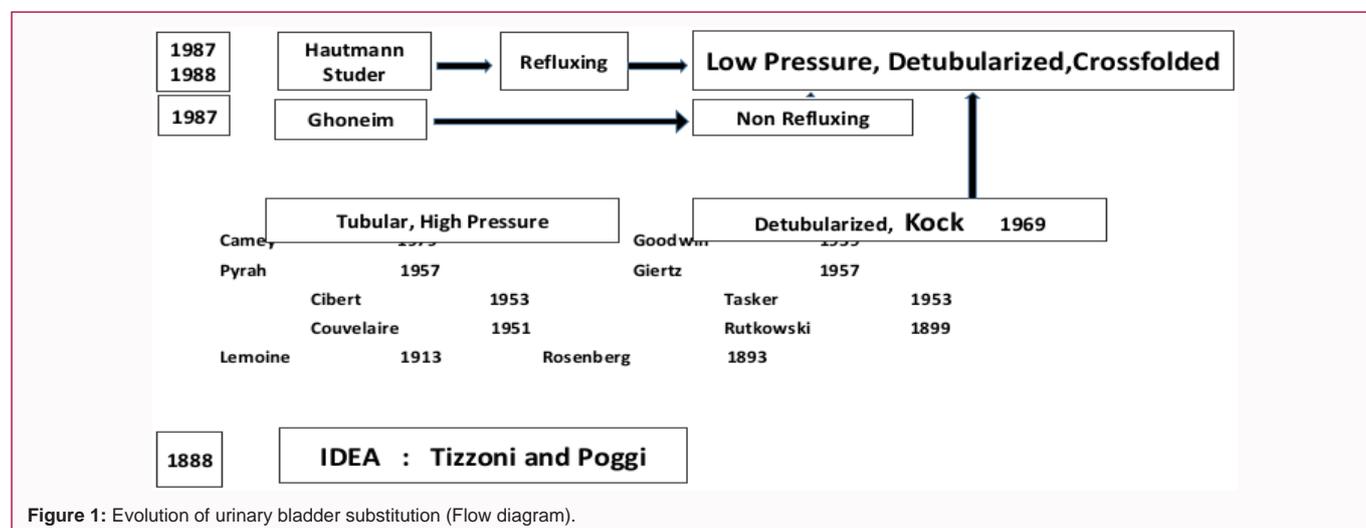


Figure 1: Evolution of urinary bladder substitution (Flow diagram).

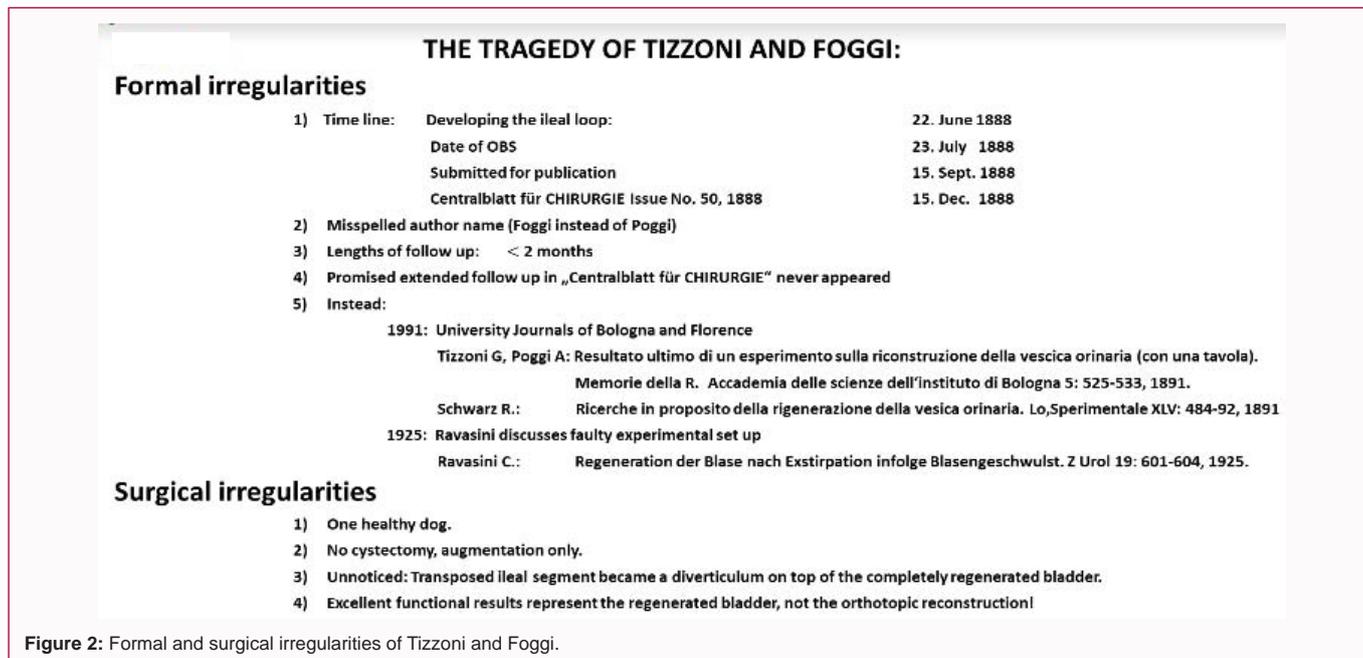
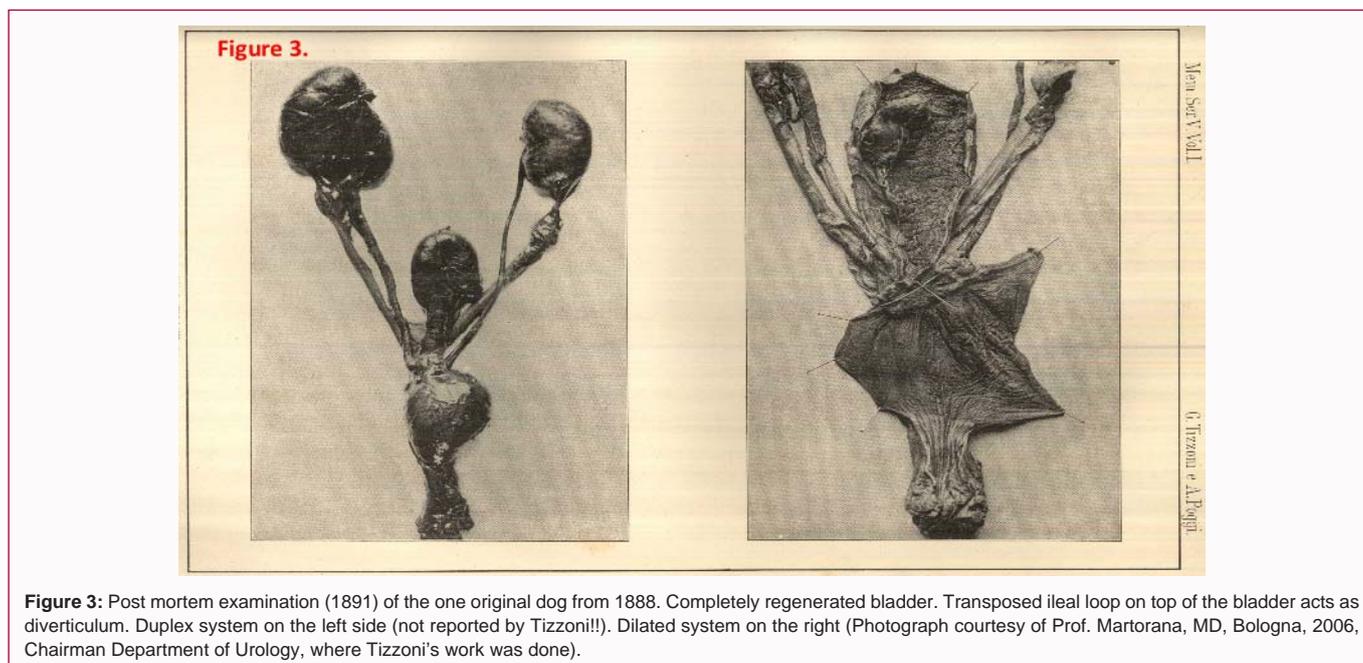


Figure 2: Formal and surgical irregularities of Tizzoni and Foggi.



the volume of the human bladder. What he actually did was a classic bladder augmentation in one patient. Also unrecognized went the earlier work of Rosenberg [17]. He repeated Tizzoni and Foggi's experimental setup, but used for the first time detubularized bowel in a dog experiment. Five years after the idea of OBS all components necessary to construct a low-pressure reservoir were available, if only the literature search was adequate.

Ileo-ureterostomy

In 1911 Coffey showed in his landmark experiments, initially also a milestone of OBS the principle of a flap valve anti-reflux procedure which is non-obstructive but non-refluxive [18]. Generations of urologists have been educated with the firm believe that any ureteral implantation needs reflux protection. Consequently all OBS initially had an anti-reflux mechanism: Ileal Neobladder [19,20] (Le Duc),

ileal bladder substitute [21] (anti-reflux nipple or long afferent tubular isoperistaltic segment), and the urethral Kock-pouch a nipple valve [22]. However, the routine of anti-reflux ureteral implantation was born in the era before the advent of designated low-pressure reservoirs and before their physiology was fully understood. Since 1996 the anti-reflux mechanism of the Ileal Neobladder (INB) has been abandoned, the ileal bladder substitute has been modified (isoperistaltic segment only) and the urethral Kock-pouch has been changed to the serous lined ureteral tunnel (T-pouch). Ureterocolic implantation and implantation into continental cutaneous reservoirs are the only remaining types of UD that require an anti-reflux mechanism. The T-pouch and extra serosal tunnel techniques may be advantageous when anti-reflux mechanism are desired or necessary [2]. Proponents of non-refluxive techniques cite the harmful effects on kidney function caused by reflux and bacteria, the potential

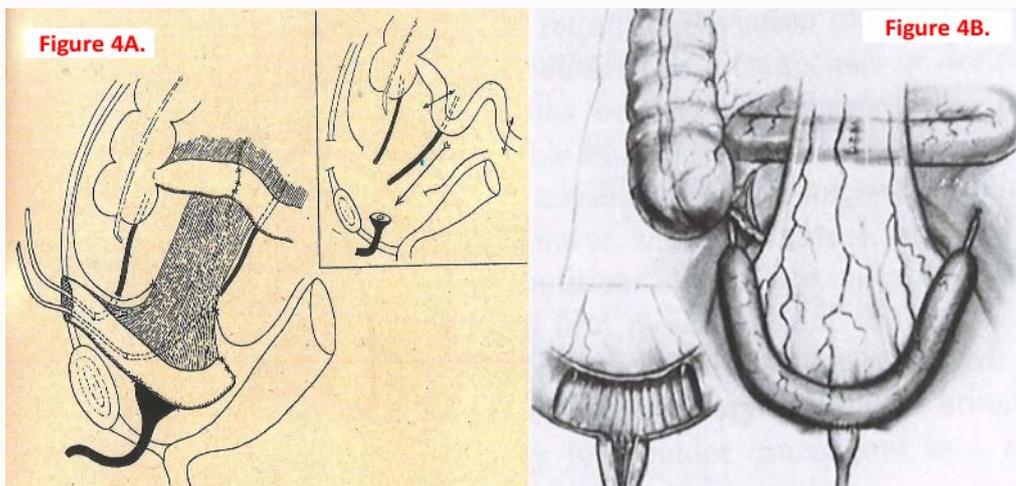


Figure 4: A) OBS as performed by Couvelaire 1951. [10] He reactivated Tizzoni's idea of an ileal bladder substitute and presented a first series of patients with OBS. Urinary continence was compromised because of persistence of peristaltic activity and intermittent high pressure peaks.
 B) OBS with ileo-urethral anastomosis: Pyrah 1957. [12] Bladder, seminal vesicles and proximal two thirds of prostate were excised. The bladder was replaced by a long loop of ileum, which was anastomosed at its middle to the prostatic urethra. Divided ureters were joined to ends of loop.

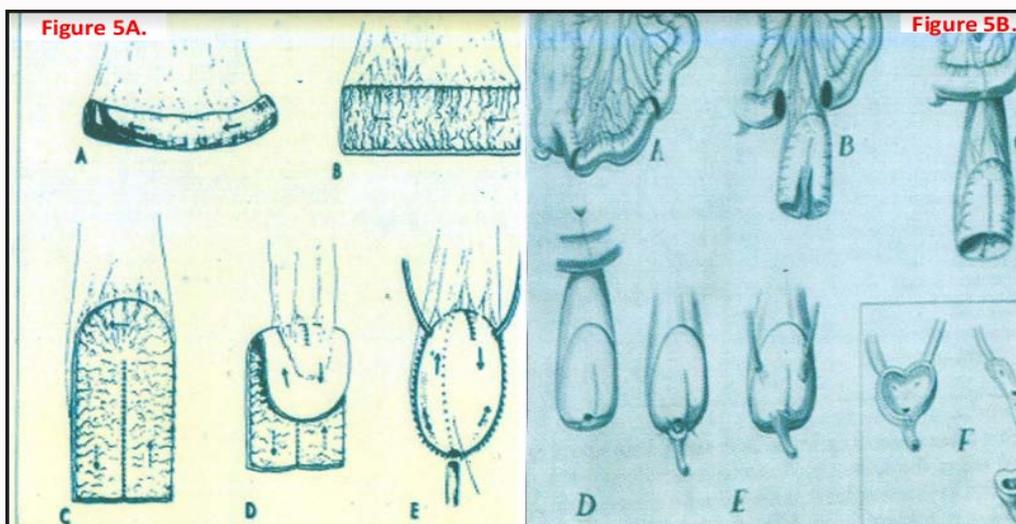


Figure 5: A) Construction of ileal bladder substitute as proposed by Kock [16].
 A: Isolated segment of distal ileum; B: Segment split open; C: Split segment folded and legs sutured together; D: Second folding; E: OBS completed. Arrows indicate direction of peristaltic movement.
 B) Construction of almost identical OBS by Giertz and Franksonin 1957 that had gone unrecognized [15].

benefit in patients requiring intermittent catheterization, and point out that reflux prevention may become more important as overall therapy for patients with pelvic malignancies improves and patients live longer with their urinary diversion, putting them at further risk for renal deterioration. Proponents of refluxive techniques cite the harmful effects of anastomotic strictures on renal function that occur at a significantly higher rate than after a refluxing anastomosis. Three randomized trials now clearly show that the firm belief that preventing reflux in orthotopic reconstructions is important is incorrect [23]. This is in accordance with the expert opinion. Most experienced surgeons have stopped creating any form of a non-reflux mechanism.

Contemporary OBS

The evolution of OBS demonstrates that only simple and reproducible surgical techniques with acceptable morbidity will

persist and be accepted. To open a tubular gut segment at its anti-mesenteric border and to cross fold it fulfill these requirements (Goodwin's Cup Patch technique) [24]. These are the two most important steps in the OBS surgical technique and must be used simultaneously. Most ileal reservoirs use 60 cm to 75 cm of the terminal ileum, which is detubularized and folded in various ways to recreate spherical shape of the native bladder. Numerous types of OBS have been described in various textbooks, including variations in the folding technique, location of the ureteroileal anastomosis and presence or absence of an anti-reflux mechanism. The pouch should be closed with absorbable sutures and metal staples should be avoided to prevent stone formation. The two most common forms of urinary diversion worldwide are the ileal Neobladder [20] (Hautmann "W") and the ileal bladder substitute with various modifications [21]. The book edited by Daneshmand [2] and the pocket guide by Studer [25], both represent in excellent form the state of the art of the OBS,

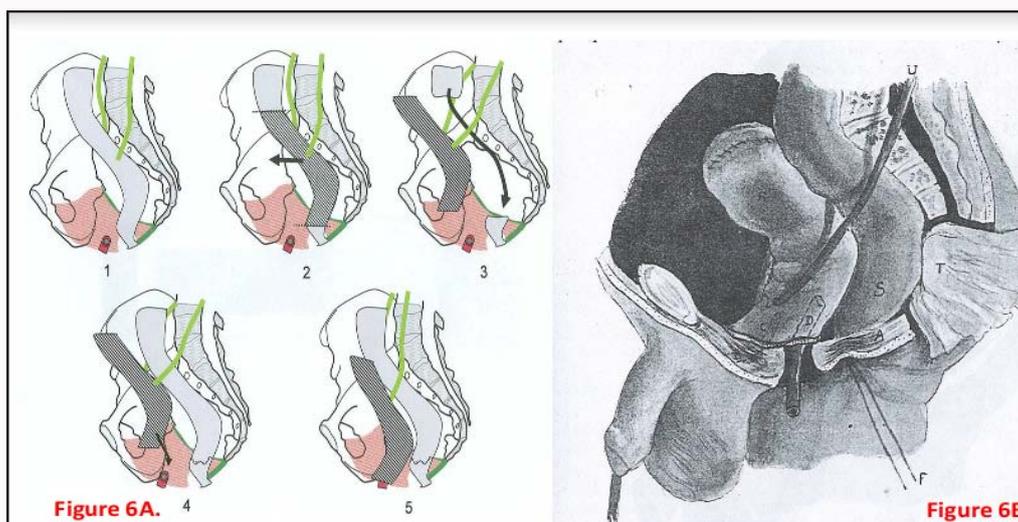


Figure 6: A) Schematic drawing of Lemoine's procedure from 1912 [4] (Courtesy of R.C. de Petriconi, MD, University of Ulm, Department of Urology). Following RC and ureterosigmoidostomy for BC (1) a rectal bladder was transposed ventrally (2+3) to anastomose it with the urethra (4+5). The descending sigmoid colon was pulled through the anus (5). Because of an abscess Lemoine had to reanastomose the rectal bladder to the anus and perform a colostomy. At the 18th postoperative day the patient died from sepsis with a cloacae [4].

B) Lemoine's original figure [4]. C: catheter, D: perineal drain, S: sigmoid, T: Mickulicz tamponade, U: ureter.

focusing on the INB and the ileal bladder substitute. Both afford a low pressure reservoir with a refluxing ureteroileal anastomosis and have been associated with excellent functional outcomes. They use a long ileal segment, have maximum detubularization and are cross folded. At the same time they avoid unsatisfactory folding, use of a U-shaped reservoir, a too short gut segment, or partial detubularization. Regrettably, there is a trend to use these negative features of the past to speed up the operation by the robotic surgeons. An example is the Y-shaped intracorporeal OBS, which is used to shorten the construction time [26].

Discussion

Since its very beginning in the 18th century, UD's goal was to replace (all) bladders. This goal has not been achieved. The idea of OBS was born in 1888 by Tizzoni and Foggi [6]. Exactly 100 years later it became a standard procedure. Why 100 years? The tragedy of Tizzoni and Foggi was not so much their faulty experimental set up, as much more the fact, that they withheld their failure. Almost all subsequent surgeons have limited themselves to preliminary good results and ignore poor final results. Slapdash literature search has propagated misinterpretation of data that has crept into the literature [27]. In addition the early criticism from Schwarz [8], Rosenberg [17], Rutkowsky [14], Ravasini [9], and later by Johnson [28] on Tizzoni and Foggi's failure have been ignored. The tragedy of Tizzoni and Foggi is thus repeated f. i. 80 years later by Bourque [29]. His long term results of OBS with anon-detubularized large bowel were disastrous. Pioneers such as Couvelaire [10] and Cibert [11] were the first to use OBS in large patient series and reported the first long term results but also used tubular ileum, what resulted in a compromised continence. This holds true for Lilien and Camey [13] in 1984. In an attempt two reduce the construction time of the reservoir there is an increasing trend of the robotic surgeons to return to these simpler reservoirs of the past, again with imperfect continence.

The extent to which Tizzoni and Foggi [6] resected the bladder in dogs remains unclear. They reported resection down to the trigone with subsequent implantation of the ureters into the sidewalls of the

loop. However, the report falls short to describe the duplex system seen in the final pathology report of the specimen after the dog had been sacrificed in 1891 [7]. Since their laboratory did research work on bladder regeneration they should have known that bladder regeneration in a dog, but not in humans, is the rule, as long as only a subtotal cystectomy is performed [5]. Of note, till way into the 19th century "cystectomy" was defined differently from what it is nowadays. It did not include the prostate and frequently did not include the bladder outlet.

Intentionally, this analysis of the evolution of OBS does not mention numerous attempts and forms of OBSs proposed during the last 25 years, because they could not stand the test of time for obvious reasons. The long-term impact of these procedures on kidney function and metabolism are known. However, two early attempts of OBS are noteworthy. First: The first case of OBS in humans was reported already in 1912 by Lemoine [4] (Figure 6a, 6b). This was a courageous as well as doubtful operation. The author concludes that the concept of OBS is worthwhile to follow, continence and reservoir capacity to be the only open questions. Second: In 1970 Ong [30] recognized that the principles of a BC operation include the removal of the prostatic urethra. He was impressed by the difficulty of anastomosing without tension an ileal pouch to the membranous urethra. Because of the difficulty encountered in this first case in all of his following patients the sigmoid colon was used. In his Hunterian lecture delivered at the Royal College of Surgeons of England he states: Following the example of Hunter, the experimentalist, who stated: "Don't think, try it ..." we performed the operation on 28 patients.

There are some limitations. Beginning with World War II English became the language of international science, what was before German. Consequently the references of this article are in German for those coming from the 19th and the first half of the 20th century. Many of the older papers are in German, and the rest include contributions from Italy, France, and Belgium. Most authors have not reported this in their native languages. All the modern literature is available in English. Second, the libraries in Bologna, Italy, and Leipzig, Germany, were not willing to hand out the original contributions,

but only copies, which were of low quality. This applies particularly to some figures.

Conclusion

After exactly one century (1888-1988) OBS characterized by a completely detubularized, cross folded, preferably refluxing ileal low pressure reservoir has arrived at its final technique. The discrepancy between surgical ambition and disillusioning outcomes must be mastered. The faulty experimental set up of Tizzoni and Foggi had been repeated by surgeons for decades, rather than being improved. Without publishing their promising preliminary results and withholding desolate long term outcomes, countless animal experiments and suboptimal procedures for patients could have been avoided. A sloppy literature search also plays a key role in the delayed development of OBS. Detubularization and cross folding have been finally integrated into the technique of OBS after a delay of many decades. It is important that we learn lessons from the past and do not make the same mistakes for the future.

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