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Review Article

Brief chronological progress in the management of intussusception: 1674 to 2021

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ABSTRACT

This is a review of the literature related to the progress in the management of intussusception. Literature and other publication on the topic of "intussusception" were retrieved from 1674 to August 2021. The online literature search was – performed using various websites, i e, PubMed, PubMed central, ResearchGate, and Google - eBooks, Google Scholar, and Google Images. The important historical events that occurred in the management of intussusception were briefly presented in this manuscript.

Keywords: Adult, Children, Chronology, Infant, Intestinal obstruction, Intussusception

INTRODUCTION

The word "intussusception" is derived from the Latin words, "intus" which means within, and suscipere" which means to receive.[1,2] It is the invagination of a segment of the intestine into the adjacent segment of the intestine.[3,4] In the literature, at least 12 names have been used to describe intussusception.[5-7] In 1742, Cornelius Henricus Velse, first successfully operated upon 50-years old women for intussusception.[8] The clinicopathological features of intussusception were first time described by John Hunter.[9,10] Dr. John R Wilson, in 1831, first time, successful operative reduction of intussusception was performed in an adult.[11] Forty years later, in 1871, Sir Jonathan Hutchinson, reported the first successful operative reduction of ileocolic intussusception in a child.[12,13] This manuscript is a brief review of chronological progress that occurred in the management of intussusception over a period from 1674, to August 31, 2021.[1-56]

DISCUSSION

The online literature, e-books, and other works were retrieved relating to the management of intussusception from 1674, to August 31, 2021. The word intussusception was first used in 1707.[1,2] At least 12 names have been used in literature to describe intussusception. The names used in literature are namely, intussusception, intus-susception, introsusception, invagination, double intrusion, inflammatory invagination, invagination of the death struggle, miserere, miserere mei, volvulus incompletes, iliac passion, prolapse, and ileus.[5] In 1674, it was first mentioned as the "intestinal invagination" by Paul Barbette (1620-1665) of Amsterdam. He also suggested the possibility of operative reduction for the illness. Paul Barbette was a famous Dutch (not by birth) surgeon and physician of the seventeenth-century and published his first book on surgery in 1655 titled "Chirurgie nae de hedendaegsche praktijk beschreven".[6,7] In 1742, Cornelius Henricus Velse, the Hague Dutchman, first successfully operated upon a 50-years-old woman for intussusception. She lived for twenty-year afterward.[8]

Table 1: Summary of chronological progress in the management of intussusception: 1674 – 2021.

S. no.	Name of author(s)	Year	Event / description
1.	Barbette[6,7]	1674	Intussusception was first time mentioned as the "intestinal invagination".
2.	Velse[8]	1742	First successful operation done for intussusception in adult.
3.	Hunter[9,10]	1789	First description of clinicopathological features of intussusception.
4.	Wilson[11]	1831	First operative reduction of adult intussusception was done in USA.
5.	Hutchinson[12,13]	1871	First operative reduction of intussusception was done in a child.
6.	Hirschsprung[14]	1876	First time reported non-operative reduction of intussusception.
7.	Treves[9,15,16]	1885	First reported the pathology and management of intussusception. Classification of intussusception based on its anatomical location.
8.	Roentgen[17,18]	1895	Discovery of the X-ray at the University of Würzburg, Germany.
9.	Roentgen[17,18]	1901	The world's first "Nobel Prize in Physics" was awarded for his invention of the X-ray.
10.	Hirschsprung[19]	1905	Published a series of 107 cases of non-operative, hydrostatic enema reduction in the treatment of intussusception in children. The reported mortality for above therapy was 35% only.
11.	Kock et al[20]	1912	Published report of 400 cases of intussusceptions in children.
12.	Ladd[21]	1913	Published first radiographs of contrast enema of intussusception.
13.	Lehmann[25]	1913	First time reported the roentgenographic diagnosis of intussusception.
14.	Olsson[26] Pouliquier et al[27] Retan[28]	1927	Reported their experience of non-operative, hydrostatic reduction of intussusception under the fluoroscopic control.
15.	Stephens[29] Arntzen et al[30]	1928	Reported their favorable results of non-operative, hydrostatic reduction of intussusception, under the fluoroscopic control.
16.	Hipsley[31]	1935	Published analysis of 486 cases of intussusceptions, treated surgically by ten-surgeons with a mortality of 11% only.
17.	Ravitch et al[32]	1948	Published results of 33 intussusception cases treated by barium enema reduction without any mortality.
18.	Hounsfield[33]	1971	He invented the "Computed Axial Tomography" (CAT).
19.	Hounsfield[33,34,36]	1971	The world's first CAT scan of the human brain was performed.
20.	Hounsfield[33,34,36]	1979	He was awarded "The Nobel Prize" in Physiology/ Medicine for his invention of the computed axial tomography scan.
21.	Parienty et al[37]	1981	Report of the world's first CT scan of intestinal intussusception.
22.	Weissberg et al[41] Weill et al[42]	1977	Published ultrasonographic (USG) reports of intussusception in Adults.
23.	Kim et al[43]	1982	First report of USG guided hydrostatic reduction of intussusception.
24.	Guo et al[44]	1986	Reported results of air enema reduction of 6396 intussusception.
25.	Wang et al[45]	1988	USG guided hydrostatic reduction of 377 intussusception cases in children was reported with a success rate of 95.5%.
26.	Saw et al[46]	1993	Introduced first laparoscopic reduction/resection of bowel for the treatment of intussusception.
27.	Huang et al[47]	1993	Reported the successful reduction/resection of bowel for intussusception by laparoscopic methods.
28.	Cuckow[48]	1996	Reported the successful reduction/resection of bowel for intussusception by laparoscopic methods.
29.	Chen et al[50]	1996	Published experience of minimal access surgery done in 574 children,
30.	Hong et al[51]	2019	Reported a systematic review of 1229 Adult intussusception, and revealed that the rate of malignant and benign tumors and idiopathic etiologies for it were 32.9%, 37.4% and 15.1%, respectively.
31.	Tsou et al[52]	2019	First meta-analysis for assessing the diagnostic accuracy of ultrasound for intussusception in children done at "point of care" and done at "radiology".
32.	Litz et al[53]	2019	Systematic review and meta-analysis reports for evaluating outcome between inpatient and outpatient management after enema reduction for

Continued.

S. no.	Name of author(s)	Year	Event / description
			intussusception. The meta-analysis findings suggest that the outpatient management may be safe and could reduce utilization of hospital resources.
33.	Kelley-Quon et al[54]	2021	Published the results of a systematic review done of the management of pediatric intussusception. They suggested that in hemodynamically stable children, non-operative outpatient management for intussusception should be maximized and if required laparoscopic techniques may be used to avoid the requirement of laparotomy.

Clinicopathological features of intussusception were -first described by John Hunter (1728-1793), and he also suggested the possible mechanisms by which the disease occurs. In 1789, he presented a 9-months old child of intussusception who subsequently died of his illness. He published the same in 1793.[9,10] In the United States of America, the first operative reduction of intussusception was successfully resorted by Dr. John R Wilson of Rutherford County, Tennessee, in December 1831. He had operated on a 20-years-old man who suffered from the illness for the past 17-days. His recovery was reported rapid and entire.[11]

In 1871, Sir Jonathan Hutchinson (1828-1913) reported the first successful laparotomy and operative reduction of ileocolic intussusception. The operative procedure was -performed at the London Hospital, under chloroform anesthesia, upon a 2-years-old girl. The operative procedure was short, and the postoperative recovery was excellent. He had published the same in 1874.[12,13] In 1876, Harald Hirschsprung of Copenhagen first reported a non-operative, hydrostatic enema reduction method for the treatment of intussusception.[14]

In 1885, Sir Frederick Treves (1853-1923) published his experience relating to the pathology and management of intussusception. He also provided the classification for intussusception based on its anatomical location. He differentiated/distinguished idiopathic intussusception (non-evident exciting causes) from the cases associated with pathological lead points. He performed laparotomy in 33 patients for intussusception with an overall mortality of 73%. He documented that the presence of bowel gangrene in childhood intussusception was invariably fatal.[9,15,16] Treves is best to remember for his work on appendicitis. He had performed an appendicectomy and drainage of an appendicular abscess of King Edward VII and saved the life of the Monarch in 1902.[15,16]

Wilhelm Conrad Roentgen (1845-1923) was a German physicist, who on November 8, 1895, first discovered the X-ray at the University of Würzburg, Germany. He was -awarded the world's first "Nobel Prize in Physics" in 1901 for his invention of x-ray. He is - referred to as the father of diagnostic radiography.[17,18] The discovery of the x-ray was later on- also implemented for the diagnosis and monitoring of the hydrostatic enema reduction therapy of intussusception.

In 1905, Harald Hirschsprung (1830-1916) published his experience of non-operative, hydrostatic enema reduction in the treatment of intussusception in children. He published his experience of 107 personal cases of intestinal obstruction/intussusception in children treated at the Queen Louise Children Hospital in Copenhagen during 1871-1904. He concluded that the mortality of the above therapy for intussusception in children was only 35%.[19]

In 1912, Kock et al published their report of 400 cases of intussusceptions in children from Denmark. They reviewed 397 intussusceptions gathered from Denmark, and those were -treated during 1980-1909. They also included 107 cases of intussusception earlier published/reported by Hirschsprung. They published detailed comparative results of non-operative (bloodless treatment) versus operative treatment for intussusception. The results of non-operative hydrostatic reduction of intussusception were superior.[20]

In 1913, William Edwards Ladd (1880-1967) of Boston published the first radiographs of contrast enema showing intussusception. He used bismuth per-rectal to- partially reduce the intussusception to facilitate surgery in a child.[21] William Edwards Ladd is best-regarded as the "Father of Pediatric Surgery" for his contribution to the development of pediatric surgery.[22,23] In 1913, Snow and Clinton reported the first case of intussusception diagnosed by the x-ray. They used barium enema for taking radiographs and published the same along with their case reports.[24] In 1913, Lehmann first time also reported the diagnosis of intussusception made by roentgenography.[25]

1927 was the beginning of the new era in the management of intussusception. Various authors reported their experience of non-operative, hydrostatic reduction for intussusception under fluoroscopic control.[26-28] Olsson et al, Pouliquier et al, Retan, Stephens, and Arntzen et al reported their favorable results of non-operative, hydrostatic reduction, barium enema reduction of intussusception under fluoroscopic control.[26-30]

In 1935, Hipsley from Sydney published an analysis of 486 cases of intussusception, treated by ten surgeons from 1921 to 1934. The reported overall mortality was 11% only. The important fact of this study was that 3 of the surgeons used a per-rectal injection of saline before the operative procedure. The combined mortality for above

was 9.8% only. Other seven surgeons primarily operated on all their cases of intussusception without prior saline injection. The combined mortality for patients that were - operated on by above seven surgeons was 14%.[31]

In 1948, Ravitch et al (1910-1989) published their results of 33 patients of intussusception treated by barium enema reduction without any mortality. Twenty-four of their cases were reduced- by the barium enema alone. They documented that the morbidity and length of hospital stay were much less when compared with those patients primarily treated by operation during the same period. They also described their technique of barium enema reduction for intussusception in detail.[32]

Sir Godfrey Newbold Hounsfield (1919–2004), a biomedical engineer at Electrical and Musical Industries Limited (EMI) Hayes, London, United Kingdom, invented the "Computed Axial Tomography" (CAT) in 1971.[33] He was awarded "The Nobel Prize" in Physiology / Medicine for 1979 for his invention of the computed axial tomography scan. The Nobel Prize for 1979 in Physiology / Medicine was awarded to him, which he shared with "Allan MacLeod Cormack".[34,35] The discovery of the CAT scan changed the entire face of medical science, not only in the field of diagnosis but also for therapeutic uses. On October 1, 1971, the world's first CAT scan of the human brain was performed at Atkinson Morley Hospital, Wimbledon, London.[33,34,36] In 1981, Parienty et al reported the world's first CT scan report of intestinal intussusception, performed in a 36-years-old man.[37] CT scan of the abdomen was added as a diagnostic tool for intussusception, is more frequently utilized in adults.[38-40]

Ultrasonography (USG) is a gold standard diagnostic tool for intussusception in children. In 1977, Weissberg et al, and Weill et al published their USG reports of intussusception in adults.[41,42] Currently, in children, hydrostatic/pneumatic reduction of intussusception under sonographic guidance is the preferred treatment method. Sonographically guided hydrostatic reduction of intussusception in children was described first by Kim et al in 1982.[43] In 1986, Guo et al reported the results of air pressure enema reduction of 6,396 intussusceptions treated at the Shanghai Children's Hospital during 13-years.[44] In 1988, Wang et al published a report of 377 pediatric intussusception cases treated during the years October 1985 to April 1987. They treated the above-mentioned cases by normal saline hydrostatic reduction under ultrasound guidance with a success rate of 95.5%.[45] The advantage of USG guided hydrostatic/ pneumatic reduction of intussusception is avoidance of the potential hazards of irradiation.

Laparoscopic reduction/resection of bowel for intussusception was first- introduced in 1993. In 1993, Saw et al reported a case of Meckel's diverticulum in an adult that had intussuscepted into the distal ileum. She was treated successfully by laparoscopically assisted reduction of intussusception and resection of the diverticulum.[46] Huang et al, Cuckow, and Schier reported the successful reduction/resection of bowel for intussusception by laparoscopic methods.[47-49] Chen et al, in 1996, published their experience of minimal access surgery (MAS) done in 574 pediatric cases over five years from January 1, 1990, to December 31, 1994. They reported that the overall complication rate of MAS was 4%, and there were no deaths. This report was one of the first largest series regarding MAS done in children, aged one month to 19-years. They concluded that, in children, MAS can be used safely for a wide variety of diseases, with minimal morbidity and mortality.[50]

In 2019, Hong et al reported the results of a systematic review and meta-analysis of 1229 adult intussusception and found that the rate of malignant and benign tumors and idiopathic causes for it were 32.9%, 37.4%, and 15.1%, respectively.[51] In 2019, Tsou et al reported the results of a systematic review and meta-analysis of the accuracy of ultrasound for the diagnosis of intussusception in children. They summarize that the ultrasound has excellent sensitivity and specificity in detecting childhood intussusception. They further added that the diagnostic accuracy of ultrasound done at the point of care is not significantly different from that of ultrasound was done at the radiology.[52] In 2019, Litz et al reported the results of a systematic review and meta-analysis of inpatient and outpatient management after enema reduction of intussusception. They found that the overall recurrence rate was 8% of outpatient and 6% of inpatient management. They concluded that the findings of the meta-analysis suggest that the management of intussusception after enema reduction as an outpatient may be safe and could reduce the utilization of hospital recourses.[53] In 2021, Kelley-Quon et al concluded the results of a systematic review done of the management of pediatric intussusception. They concluded that in hemodynamically stable cases, pre-reduction antibiotics are unnecessary. They further suggested that non-operative outpatient management for pediatric intussusception should be maximized and if required laparoscopic techniques may be used for the same to avoid the requirement of laparotomy.[54]

Robotic Surgery (Robotic-Assisted Surgery) is one of the most recent surgical techniques employed across all age groups.[55,56] On April 11, 1985, a world-first robotic-assisted brain biopsy in an adult was - performed at Long Beach Memorial Medical Center, California.[55] The first robotic-assisted surgical procedure in a child was undertaken in March 2002 by Peter et al.[56] Robotic-assisted reduction/bowel resection for intussusception has not been performed probably, to date.

CONCLUSION

Intussusception is one of the common causes of intestinal obstruction in infants and younger children, but it also occurs in older children and adults. Most of the advancement in the management of intussusception

occurred during the last seventy years. In children, non-operative, hydrostatic reduction of intussusception was-introduced by Ravitch et al in 1948 remains the gold standard for uncomplicated cases. Ultrasonography was introduced as a diagnostic tool for intussusception during the 1980s. It is now routinely used for the diagnosis, and monitoring of the non-operative hydrostatic/pneumatic reduction of intussusception. Surgical therapy is reserved for the cases that failed non-operative reduction, suspicion of bowel gangrene, or presented with perforation peritonitis. Laparoscopic/laparoscopic-assisted reduction/ resection of bowel for intussusception is also a preferred method for the management of intussusception.

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