

## Surgical Drains – A Review

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### ABSTRACT

The requirement of different types of drains is an important modality in surgery. A drain is an equipment that acts as a medium for the escape of gaseous components, body fluids, and other material from the body cavities, surgical site, or infected focal areas. Hence, it plays an important role in a variety of surgical procedures. Surgical drains of various types are being used in different surgical procedures over the years. They have been used for ages but with time, there has been a shift with the type, quality, and the mechanism by which it functions.

A systematic literature review search was performed in Medline, PubMed, Global Health, Web of Science, Scopus, Cochrane, POPLINE, Open Grey Database, ADOLEC, PATH, Gavi, WHO websites, up to June 2020. The list of reference articles was retrieved, and they were searched via automation & manually by using the search terms “surgical drains”, “drain fixation”, “mechanism of the drain” & “drain types”.

This article presents a brief review regarding the concept of introduction and the changes that have been done to suit evolving times and accommodate new aspects of surgery. Should drains be used and for how long? a complicated question; but the diversity of answers is suggesting that no specific type is accurate. Every situation must be considered on its merit, and the most appropriate drainage method and material should be carefully selected. The origin of this question can be answered by a brief review of surgical drains, how their use came into being and the change it has undergone with evolving times over the course of history. Furthermore, the complications associated with its use and how they were dealt with should be understood.

#### KEY WORDS

Prophylactic Abdominal Drainage, Wound Infection, Drain Fixation, Intraperitoneal Drainage, Surgical Site Infection (SSI) or Risk Factors

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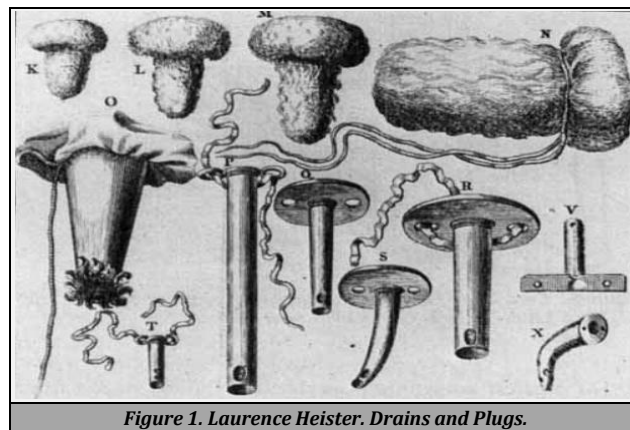
## BACKGROUND

In the field of surgery, usage of drains has always been an important component.<sup>1</sup> Initially surgeons came out with different rudimentary variants. Many variants have been launched over the years but their functions continue to remain the same; that is to prevent the accumulation of bodily fluids and thereby improving the haemodynamic status of the patient.<sup>2</sup> Hippocrates was the first one to ever document the use of surgical drains which he used for the treatment of empyema. It was rudimentary but the concept was simple, hollow tubes were used through which collected pus in the thorax was drained, detected via moving the chest and listening for the splashing sounds. The<sup>3</sup> side of the chest with the greatest quantity would be drained first. He rationalised this with a medicinal approach and the prognosis improved.



In 1363 French surgeon Guy de Chauliac wrote a book on the modern ethics of surgery, named "Chirurgia Magna"<sup>3</sup> in which he described a tool known as 'charpie'. It's a drain consisting of linen which is cut into multiple small pieces and 'Tents' made by rolling charpies between the hands to form a stiff tampon with one end shaped like a tail. They were used as wicks to prevent premature closure of a wound. Claudius Galen using the above principle used leaden composed hollow tubes for the management of ascites while Erasistratus of Alexandria used the principle to demonstrate the use of urinary catheters in surgery. Other known figures in our history did have significant contributions during the period of renaissance particularly Ambroise Park.<sup>5</sup> His description regarding the functionality of drains and the use of packs required as an emergency for wound packing played a big role in world war 1. He further used anti corrosive materials like gold and silver for drainage of ascites.

Johannes Scultetus (1595 - 1645) premier surgeon of his time (17<sup>th</sup> century), recommended and applied the principle of capillary drainage via insertion of a wick into a drainage tube to increase its efficiency.<sup>6</sup> His theory was further promoted by Laurence Heister who championed the use of Penrose drains which became very popular in the latter years.



Koeberle of Strasbourg in 1857 introduced glass tubes with solid ends and perforated sides with small minute inlets which allowed drainage but prevented obstruction from abdominal contents. It was further studied by Chassaignac in 1859 who replaced glass tubes with red rubber hollow tubes as a glass tube could perforate the abdominal organs or can cause tissue damage, this was a very most important step in the development of drainage as these types of tubes continue to be used even today. This principle has formed the base even for the modern days treatment of thoracic conditions such as haemothorax or pneumothorax. Later the trend of using tubes for the treatment of fluid collection within the body started. Aurelius Celsius of Rome used this concept and started performing surgeries where lead & brass conical tubes with modifiable plugs were used for the management of ascites.<sup>4</sup>

## REVIEW QUESTION

What is the history behind surgical drains and how has it impacted modern day surgery?

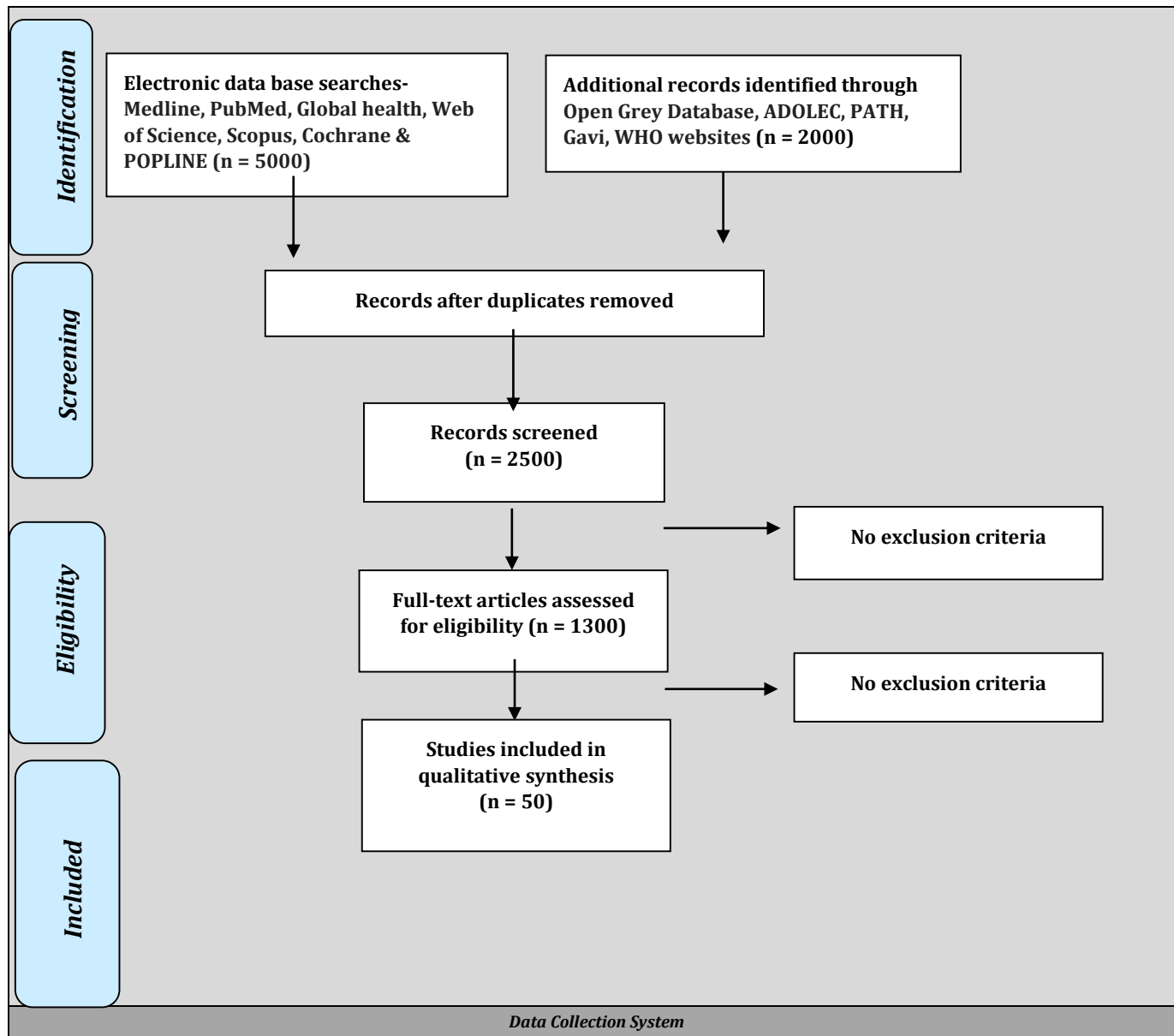
## METHODS

### Search Strategy

A comprehensive set of keywords or search terms were built like "surgical drains", "drain fixation", "mechanism of the drain" & "drain types". A systematic literature review search was performed in Medline, PubMed, Global Health, Web of science, Scopus, Cochrane, POPLINE, Open grey database, ADOLEC, PATH, Gavi, WHO websites up to June 2020. The list of reference articles was retrieved, and they were searched via automation & manual.

### Data Extraction

Data extraction was done by 2 authors in separate sheets using Excel 2020. Article selection and data extraction discrepancies were resolved through discussion. No specific date was predefined regarding publication. Automated & manual deduplication was performed.



## DISCUSSION

The concept presented by Chassaignac’s tubes was used by Keith and Sir Thomas Spencer Wells who followed this pattern but later modified the glass tubes thereby making it more cylindrical with both ends left open while retaining the small perforations within it. Sims carried out a lot of research over this subject, he wanted to change the use of soft rubber tubes into a hard one to reduce the pelvis of the peritoneal ‘secretions’, which he believed led to fatal septicaemia post gynaecological surgeries. Though it was pre-emptively decided to place a drain, because the drains would eventually get blocked. Failure brought a reaction against prophylactic drainage.<sup>7</sup>

Schroeder in the year 1875 brought about a new principle in surgery which stated that the peritoneal secretions during surgery cannot be avoided rather proper care to be taken to avoid preventing sepsis from the same. Vagina was not a site for drain insertion as it could not be sterilised, but risk was very high as it could cause vesicovaginal fistula or rectovaginal

fistula or even uterovaginal fistula as it can perforate the surrounding structures. This was pointed by loebker.<sup>8</sup>

Our review of history shows us that there were many people from the nonmedical background who have suggested something new in this field. Captain Creighton got injured below the umbilicus during his fight in the battle of airs.<sup>9</sup> The captain devised some hollow tubes which he inserted into his wound that allowed the passage of pus and had a full recovery. He has been credited with the introduction of tubes as a means of drainage in the abdominal cavity.<sup>10</sup>

The first-ever successful laparotomy was conducted by McDowell in 1809 who brought the drain to the surface via the abdominal wound through a long silk suture with its end tied to an ovarian pedicle: thus, the ever-pre-emptive use of a drain was done.

Peaslee in 1855 had placed a gum elastic catheters per vaginam into the pouch of Douglas during pelvic surgery, but he gave credit to his assistant Dr. Clough. Chassaignac of France (1859) deserves credit for the invention of the rubber drainage tube.<sup>3</sup>

The year 1881 gave us a new concept in the mechanics and the materials that were used to make drains. Mikilicz used gauze pieces that were cut in the form of long strips. Tincture

iodine was applied on them which were inserted into sheets of rubber. They were left inside the intestine to keep the loops from coming out and the gauze provided a pathway for drainage and reducing the deadspace.

His studies were further researched and practically applied by William Halstead. By the end of the century these tubes became a common feature in the surgical practise in the United States. However, the increase in usage also led to increase in the number of complications i.e post-operative complication rate had sky rocketed during this period.

There was a catch regarding these rubber drains, as they had to be removed within 48hrs to allow the cavities to collapse as shown in the (Figure 4). Modifications were made over a period of time, for example by Kehrer who modified the inner tubes to allow cleansing at regular intervals.

Yates used this concept in tracheostomy tubes, which are used even today, as it is more viable and helps in preventing complications. Over a period of time many modifications were made like Skeins who used catgut which was theoretically sensible but practically was not possible as local reactions would arise.

One of the heavyweights in gastrointestinal surgery Theodor Billroth believed that drains had a key role in the future of surgery, but others continued to have a negative opinion of the same. There was a specific natural rubber material called gutta-percha that he preached about, today known as the 'cigarette' drain.

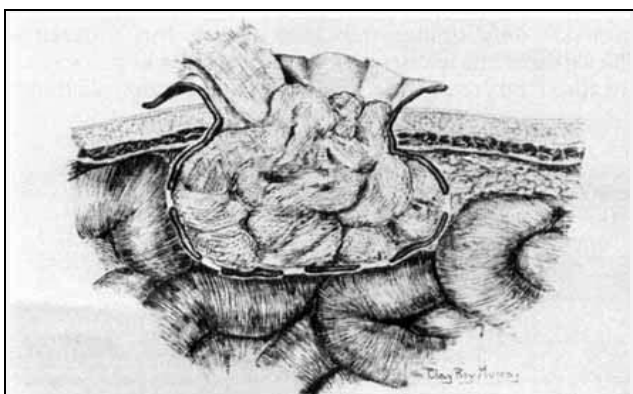


Figure 2. Rubber Dam Mikuiicz Tampon. Gibson CL

Nueber was the first man to ever use animal bones in the development of drains, he used decalcified ox bones though it had an advantage of absorption rate of 6 - 20 days, however, it did create a huge controversy and objection among the Hindu population for their religious sentiments.<sup>11</sup>

It was further developed by Beyer who used aorta of oxen, which had similar objections and got rejected.

Bardenhaur tried adding catgut in this, by tying it around the tube to prevent adhesion and if required can be moved or mobilised. Nicaise used a different type of rubber which was colour coated as the normal ones had high content of sulphur which can act as an irritant. Levis used threads of rubber as it would be less irritating. Horsehair was also used as it was considered to be cheap and available and had no major issues. So, if required mass production could be done with low production cost.

Sir Lord Lister favoured using hair that is darker thus, making it more visible and viable. He proposed many more new ideas during his time, however, all of them were not considered to be viable and were rejected. He always

maintained that antiseptics, irritation from the products will continue to remain a major challenge in the development of drains.

Materials such as horsehair, catgut, wool, and string were used as wicks and inserted down the tubular drains.

One of the most popular incidences recorded in history was the case of Queen Victoria who had developed an abscess in the axilla, it was treated by Lister who used a linen drain for its management. He noticed that thick pus wasn't draining properly, and it may act as a plug. So, he started using tube drainage. He maintained using strips of rubber for about 5 years and continued to get desired results.

But his opinion and perception changed in the year 1871, when while treating a deeply seated acute abscess of the axilla he noticed that though the pus was draining properly, thick pus drained for the first time in large quantity which he had never seen before, he thus, came to the opinion that modifications can be made to further increase the rate and quantity of drainage.

It occurred to him that the lymphatics or lymph are not only serving as a drain but also a source of blockage and bacterial foci, as the incision made was very small and narrow. So, he used Indian rubber tubing type combined it with Richardson's spray producer that was used as an anaesthetic agent for local application. He modified his drains by making holes in it and attaching silks threads to one end, thus improving the drainage system. He further soaked them in carbolic acid.

He introduced these drains and observed for 2 days, on the first day, he observed thick pus as noticed previously. However, on the second day he found nothing but a drop or so of clear serum. There was a rapid decline in the overall quantity of drainage and post removal of the drain the cavity collapsed on its own, without any residual collection.

He was able to discharge his patient and follow up showed that there wasn't any post-operative complication for the same. Normally he would remove drains within 24 hrs. but he postulated that in case of abscess the drain removal should be adjusted accordingly depending upon the patient conditions and the quantity of drain. He would usually wait till the quantity decreased.

His greatest rival and critic Lawson Tait who was his competitor, for once agreed with him when he said: 'When in doubt, drain'.<sup>12</sup>

1891 Hunter R in co-ordination with John Hopkins Hospital carried out a study regarding the effect of bacterial growth over the drains. He concluded that almost 50 % of them were infected with some form of bacterial contamination or the other, thus emphasising that meticulous care and cleaning to be done to avoid bacterial proliferation.

Furthermore, there were many more problems associated with drains, as persistence of drains eventually led to development of fistulous tract, thereby weakening the muscles around the drain and leading to incisional hernia, the intestinal loops may get blocked resulting into obstruction well. There are complaints of constant discomfort, irritation and a psychological impact on the patient.

Thus, it led to the development of Penrose drains which revolutionised the way drains were opened. It continues to be used even today particularly in America. It was invented by a famous surgeon called Charles Brigham Penrose, he was a professor of gynaecology at the University of Pennsylvania.

He modified a condom that was cut and then a strip of gauze was inserted into it (Figure 3).

Objections were raised based upon the fact that it was difficult to remove them. Granulation tissue eventually would invade into the gauze pieces thus encircling them, making them difficult to remove.

Fear of damage makes the surgeon's hesitant to put pressure while removing the drains as there is a constant fear that loops of intestine particularly may get entrapped leading to damage of the entire peritoneum and prone to infection.

To prevent this the drain was surrounded by a normal rubber encased condom with the ends cut off. With this arrangement the uncertainty was avoided and the adhesions could also be kept at bay. They were sturdy but could be removed easily when required. They were sterilised by boiling them at certain temperatures. The gauze drains had to be removed within a span of 2 - 3 days. After removing it, small rubber tubes were to be kept as precautionary measure.

John Yates who resided in Chicago was presented with Senn Medal for his paper on the local effects of peritoneal drainage. He accurately described the issue of peritoneal drainage, the problem that persist event today.

He concluded that it is not possible to drain the peritoneal cavity completely as it is against the body mechanism to completely empty the cavity of fluid.

A study was conducted by Johns Hopkins Hospital regarding the importance of drains where glass rods were commonly used. It was found that nearly 50 percent of cases were infected with organisms. So, they deduced the absolute necessity of regular dressing & cleaning of drains. The aftermath of this was the development of the Penrose drain.

With the industrial age, the concept of commercialisation of drain was introduced. Chaffin was the first person to commercialise suction drain in 1934, he was a strong critic of Penrose drains and said they did more harm than good.<sup>10</sup> Initially, the suction was applied intermittently with a syringe. Because of the negative image of Penrose drains the latter's popularity soared with time.

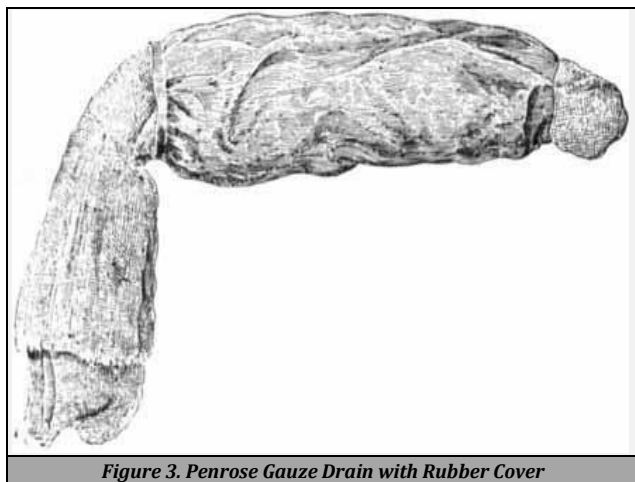


Figure 3. Penrose Gauze Drain with Rubber Cover

When the First World War broke out, the entire discussion regarding drains, their usage, mechanics and their need was put into task. Hathway though himself an expert on dead spaces condemned the usage of drains in his published articles. He believed that the drain was outdated notion and should be part of our history rather than our present and future. It is said that if those papers were studied by a larger population, we

would have had different outlook regarding drains today, probably we would even have had newer technologies. Drain usage continued resulting an increase in the complication as well. Simple capillary drains of gauze fell into disrepute, while the 'cigarette' drain of Penrose increased in popularity.

A new concept was introduced in England by a person called Heater. He described the first siphon drain by using a chemist's water-pump to produce constant suction (Figure 4). It was eventually known as Heaton's apparatus. It became the basis on which negative suction drains are placed.

Though Penrose drains were preferred because of the soft consistency they had major complications like fistula formation thus preventing the post-operative recovery period. This emphasises the need for placement and the requirement for fixation of the drain.

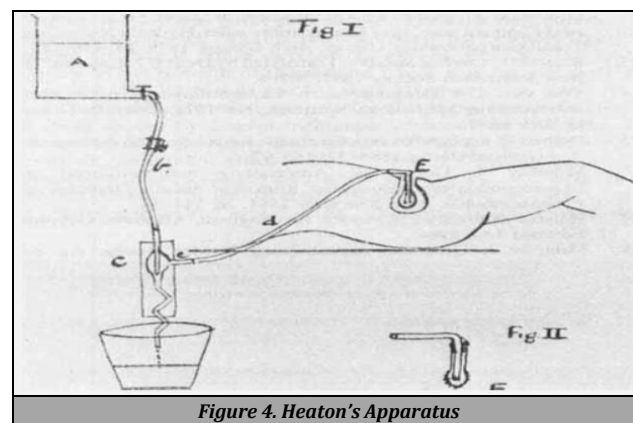


Figure 4. Heaton's Apparatus

With the development of suction drain, studies were also done regarding continuous suction. This was first proposed by Raff in the year 1952 who employed an external source of vacuum connected to the drainage tube which was open to the atmosphere. It was later brought into the market. Sealed unit drains brought about a new revolution in this field. They are currently being widely used.

### CONCLUSIONS

Drains have both pre-emptive & therapeutic usage but the chances of retrograde infection continues to remain high. The stab incision should be of a smaller calibre as compared to the actual size of the drain but should be big enough to compress the drain.

A drain should always be brought out from a different incision than the main one as the drain will affect the main wound thus becoming a source of infection of the abdominal cavity. Furthermore, the stress on the site may lead to incisional hernia.<sup>13</sup> A commonly accepted rule is that if a drain has less than 25 mL in the last 24 hours (approximately 1 mL / hr.) the drain can ideally be removed between 3<sup>rd</sup> to 5<sup>th</sup> day to prevent the development of the fistulous tract. However, there is no proven scientific data to prove the fact.

The drainage pressure may be increased with a slight increase in the negative pressure or via a more powerful positive suction pressure system as said by Dr. Collernce : "bile is not educated to climb drains".

The modality of drain system usage in surgical field continues to be a topic of heated debate. There are individuals

who strongly believe that the drain usage has no added benefits and will continue to hinder the overall patient management.

Opinions are many based on research and personal experience, but the fact remains that the fluid (5), can or will become a potential source of contamination further causing delayed wound healing. However, there are many who believe that it protects or acts an early marker for detection of anastomotic leaks & haemorrhage.

The old saying which says, "When in doubt, drain" and "it is better to have and not need it than to need it and not have it" was followed for a long time. However, it cannot be given as an answer to the ever-increasing voices that are raised against its use.

Should drains be used and for how long? a complicated question, but the diversity of answers is suggesting that no specific drain is accurate. Every situation must be considered on its merits, and the most appropriate drainage method and material be carefully selected. This policy is more practicable than a dogmatic approach.

There are many in the surgical profession who believe that intraperitoneal drainage is a useless commodity and voiced their concern; there are also those who continue to sit on the side-lines and continue to use drain as a safety valve or perhaps as a precautionary measure due to their conscience.

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Disclosure forms provided by the authors are available with the full text of this article at jemds.com.

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