International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 08 Issue: 09 | Sep 2021 www.irjet.net p-ISSN: 2395-0072

Intrauterine Device (IUD): A Review of Types of IUD Devices

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Abstract - *An intrauterine device (IUD) is a small, T-shaped birth control device that is inserted into the uterus of female to prevent pregnancy. IUDs are one form of long-acting reversible birth control and are safe and effective. The types of intrauterine devices commonly available in the market are Nonhormonal IUD and Hormonal IUD. The aim of this paper is to give a brief review about the two types of IUD's, its history, Devices and its composition, Advantages and Disadvantages, Risks, and the upcoming research in IUD's.*

Key Words: IUD's; Hormonal; Non-Hormonal; Advantages; Disadvantages; History; Risks

1.INTRODUCTION

A new study has found that contraceptive use among women's health care providers is markedly different from that of women in the general population in USA. They have concluded that female family planning providers choose Long-acting reversible contraceptives (LARC) methods more often (41.7%) than the public (12.1%) [1]. Among the various birth control methods in the LARC method, IUDs, result in the greatest satisfaction among users. IUDs are safe and effective in adolescents as well as those who have not previously had children [2].

The use of IUDs as a form of birth control dates from the 1900s. Early intrauterine devices crossed both the vagina and the uterus, causing a high rate of pelvic inflammatory disease. The first IUD was developed in 1909 by the German physician Richard Richter, of Waldenburg. His device was made of silkworm gut and was not widely used. Ernst Gräfenberg, created the first Ring IUD, Gräfenberg's ring, made of silver filaments. Jack Lippes helped begin the increase of IUD use in the United States in the late 1950s. In this time, thermoplastics, which can bend for insertion and retain their original shape, became the material used for first-generation IUDs.

The most commonly and widely available IUD in the commercial market are contained in one of the two types: Non – Hormonal IUD's (Copper-containing IUD: ParaGard and others) and Hormonal IUD's. (Progestogen-releasing IUD: Mirena and others).

This paper is a brief review of Intrauterine Devices, both Non – Hormonal IUD's and Hormonal IUD's and gives a short history, advantages, and disadvantages, risks respectively and the future works and on the IUD devices.

2. PREVIOUS WORK

There have been various reviews on Hormonal and Non – Hormonal IUD separately and their evolutions of these IUD devices respectively and IUD devices as a whole.

Among reviews of evolution of IUD devices, M. Thiery [3] gives a detailed description of the pioneers of IUD devices from early 1900's till mid 2000's. The paper also mentions some interesting facts in the history of IUD devices such as the first ring IUD ring, Gräfenberg's ring, named after Ernst Gräfenberg, German physician, made of silver filaments was banned and his work was suppressed during the Nazi regime, when contraception was considered a threat to Aryan women. He moved to the United States, where his colleagues H. Hall and M. Stone took up his work after his death and created the stainless-steel Hall-Stone Ring.

Another review by M. Thiery himself [11], gives a detailed description of the history of IUD devices as a whole, in Five generations. The First generation being the Silver Ring IUD devices, the first one named Gräfenberg's ring; The second generation being the use of Plastic devices in IUD contraception; The third generation being the Copper Bearing devices; The fourth generation being the Hormone releasing devices and the fifth generation being the intrauterine implant.

A complete review of the Non – Hormonal IUD is given by Kulier R et al. [12]. The paper gives a detailed description of the background, history, composition, various types, risks, advantages, disadvantages. This paper extensively talks mostly about Copper IUD, the most common and the only type of Non – Hormonal IUD commercially available in many countries across the globe.

A complete review of the Hormonal IUD is given by Luukkainen. T [13]. This paper talks about Device, Composition, Effects on Menstruation, Clinical Findings, effectiveness, and Treatment of menorrhagia. This paper gives a detailed description about the technical specification about Hormonal IUD. The official website of the Mirena IUD also gives a detailed description about the Hormonal IUD [14]. The website also gives a history of the Hormonal IUD and also its evolution.

Hormonal IUDs are not only used for contraception, as Non – Hormonal IUD , but also used for prevention and treatment of various diseases and symptoms of women.

Luis Bahamondes et al.[15], provides a perspective on the use of the Hormonal IUD (levonorgestrel-releasing intrauterine system) a contraceptive method and as therapy in different situations, as well as presenting the corresponding controversies and unresolved issues. This paper mentions about the use of Hormonal IUD as a treatment of Heavy Menstrual Period, Endometriosis and Chronic Pelvic Pain.

Hormonal IUDs are also used in treatment of dysmenorrhea associated with adenomyosis. Sheng, J, et al. [16], provides a detailed study of the efficacy and side effects of Hormonal IUD (levonorgestrel-releasing intrauterine system) used for treatment of moderate to severe dysmenorrhea associated with adenomyosis over a 3 – year period.

3. NON – HORMONAL IUD

A non-hormonal IUD is a small piece of flexible plastic shaped like a T that has any inert biomaterials (mostly copper) wrapped around it. Copper wire coiled around the device produces an inflammatory reaction that is toxic to sperm and eggs (ova), preventing pregnancy. The invention of the copper IUD in the 1960s brought with it the capital 'T' shaped design used by most modern IUDs. U.S. physician Howard Tatum determined that the 'T' shape would work better with the shape of the uterus, which forms a 'T' when contracted. He predicted this would reduce rates of IUD expulsion. Tatum and Chilean physician Jaime Zipper discovered that copper could be an effective spermicide and developed the first copper IUD, TCu200. Improvements by Tatum led to the creation of the TCu380A (ParaGard), which is currently the preferred copper IUD [3]. ParaGard is the only copper IUD available in the United States. It can prevent pregnancy for up to 10 years after insertion.

3.1 Device and Composition

There are several models of the copper IUD available around the world. Most copper devices consist of a plastic core that is wrapped in a copper wire. The plastic core is mostly non – reactive polymers like PVC etc. However, there are "frameless" copper IUDs available as well in which only the copper is molded into a T shaped frame. Some newer models also contain a silver core instead of a plastic core to delay copper fragmentation as well as increase the lifespan of the device. The Paragard TCu 380a measures 32 mm (1.26") horizontally (top of the T), and 36 mm (1.42") vertically (leg of the T) [4]. Copper acts as a spermicide within the uterus by increasing levels of copper ions, prostaglandins, and white blood cells within the uterine and tubal fluids. The increased copper ions in the cervical mucus inhibit the sperm's motility and viability, preventing sperm from traveling through the cervical mucus, or destroying it as it passes through [5].

Fig -1: A Copper IUD device (Paragard TCu 380A)

3.2 Advantages

- Very simple design, easy to manufacture and use and less expensive.
- The effectiveness of the copper IUD (failure rate of 0.8%) is comparable to tubal sterilization (failure rate of 0.5%) for the first year.
- Reversible, can be removed at any time. Fertility has been shown to return to previous levels quickly after removal of the device
- The copper IUD is the most effective form of emergency contraception, more effective than the hormonal EC pills currently available.
- The lifespan of the devices ranges from 3 years to 10 years; however, some studies have demonstrated that the TCu 380A may be effective through 12 years.
- The copper IUD can be inserted at any time in a woman's menstrual cycle as long as the woman is not pregnant.
- No chemical component is present in copper IUD, hence prevents complications.

3.3 Disadvantages

- The copper IUD can be spontaneously expelled from the uterus.[20] Expulsion rates can range from 2.2% to 11.4% of users from the first year to the 10th year.
- The insertion of a copper IUD poses a transient risk of pelvic inflammatory disease (PID) in the first 21 days after insertion.

- Many women feel cramping or pain during the IUD insertion process and immediately after as a result of cervix dilation during insertion.
- The copper IUD increases the amount of blood flow during a woman's menstrual periods. On average, menstrual blood loss increases by 20–50% after insertion of a copper-T IUD; increased menstrual discomfort is the most common medical reason for IUD removal [6].
- Copper is a source of allergen and has triggered many allergic reactions in body for some like skin rash, nausea, diarrhea etc, and it has sometimes proven to be fatal [7].

3.4 Risks

Copper IUDs are proven risks for females who:

- Have uterine abnormalities — such as large fibroids — that interfere with the placement or retention of Copper IUDs
- Have a pelvic infection, such as pelvic inflammatory disease
- Have uterine or cervical cancer
- Have unexplained vaginal bleeding
- Are allergic to copper or any component of ParaGard
- Have a disorder that causes too much copper to accumulate in your liver, brain, and other vital organs (Wilson's disease)

4. HORMONAL IUD

The hormonal IUD was also invented in the 1960s and 1970s; initially the goal was to mitigate the increased menstrual bleeding associated with copper and inert IUDs. The first model, Progestasert created by Tapani J. V. Luukkainen, but the device only lasted for one year of use. The preferred commercial hormonal IUD, which is currently available, Mirena, was also developed by Luukkainen and released in 1976. Intrauterine system (IUS) with progestogen, sold under the brand name Mirena, Skyla, Liletta etc., is an intrauterine device that releases the hormone levonorgestrel into the uterus. The device is a T-shaped plastic frame that is inserted into the uterus, where it releases a type of the hormone progestin. To prevent pregnancy, Mirena:

- Thickens mucus in the cervix to stop sperm from reaching or fertilizing an egg
- Thins the lining of the uterus and partially suppresses ovulation

Mirena IUDs prevents pregnancy for up to five years after insertion. In 2013 Skyla, a lower dose levonorgestrel IUD effective for up to three years, was approved by the FDA [20].

4.1 Device and Composition

The hormonal IUD is a small 'T'-shaped piece of plastic, which contains levonorgestrel, a type of progestin. The cylinder of the device is coated with a membrane that regulates the release of the drug. Skyla releases six micrograms per day and lasts for three years. The hormonal IUD releases the levonorgestrel directly into the uterus, as such its effects are mostly paracrine rather than systemic. Most of the drug stays inside the uterus, and only a small amount is absorbed into the rest of the body. The total hormone present in the device varies by product. E.g., Mirena (52mg Levonorgestrel), Skyla (13.5mg Levonorgestrel), Liletta (52mg Levonorgestrel), Kyleena (19.5mg Levonorgestrel).

Fig -1: A Hormonal IUD device (Mirena)

4.2 Advantages

- The hormonal IUD is considered one of the most effective forms of birth control. The first-year failure rate for the hormonal IUD is 0.1-0.2% and the five-year failure rate is 0.7-0.9%.[8]
- A six-year study of breastfed infants whose mothers used a levonorgestrel-only method of birth control found the infants had a lower risk of neurological conditions, compared to infants whose mothers used a copper IUD [9].
- Allergic reaction, expulsion, Heavy menstrual bleeding, and several side effects in copper IUDs are prevented.
- In addition to birth control, hormonal IUD are used for prevention and treatment of Heavy menstrual periods [15], Endometriosis, and chronic pelvic pain [17], Adenomyosis and dysmenorrhea and Anemia [18].

- Uterine perforation is less when compared to Copper IUDs .
- There is some evidence that progestin-only birth control reduces the risk of endometrial cancer.
- Risk of Infection is less when compared with Non – Hormonal IUD.

4.3 Disadvantages

- Irregular periods and spotting between periods often occur after insertion. Some women stop having periods completely, also known as amenorrhea.
- Lifespan is less when compared with Copper IUDs
- High risk of benign ovarian cysts.
- Side effects due to Hormones such as Weight gain, Headache, Nausea, Lower abdominal or back pain, Itching, Vaginal Discharge, Decreased libido etc.
- May deplete Vitamin B1 which can affect energy, mood, and nervous system functioning
- Many women feel discomfort or pain during and immediately after insertion

4.4 Risks

Hormonal IUDs are proven risks for females who:

- Are, or think they may be, pregnant
- Have abnormal vaginal bleeding that has not been explained
- Have untreated cervical or uterine cancer
- Have, or may have, breast cancer
- Have abnormalities of the cervix or uterus
- Have had pelvic inflammatory disease within the past three months
- Have had an STI such as chlamydia or gonorrhea within the past three months
- Have liver disease or tumor
- Have an allergy to levonorgestrel or any of the inactive ingredients included in the device

5. FUTURE WORKS

Events have a habit of contradicting the most careful prophet, but short of a radical breakthrough, the most likely technical solutions to the problems of IUDs follow from the discussion above. Better device design may lead to a greater compatibility between the device and the uterine fundus. Various insertion aids will become available. Assuming that future epidemiologic studies will show that threadless IUDs are indeed associated with fewer cases of pelvic infection, different detection systems can be anticipated [10].

Bioactive agents will be increasingly used. The technology for controlled release of a wide range of chemicals from IUDs at variable rates, is already well-developed. The progesterone-releasing device are available for half a decade. Its life span in the uterus is being increased. Various other progestogens (such as levonorgestrel and norethisterone) are being studied by agencies such as the World Health Organization. So far, all progestogens tested are providing further evidence for the importance of the distinction between the amount and duration of IUD-related bleeding. Progestogens markedly reduce the amount of bleeding to below that of the woman's normal menstrual loss, but, unfortunately, they increase the duration of bleeding and, especially in early months, also cause frequent intermenstrual spotting. Objective measurements have shown that antifibrinolytic agents such as aminocaproic acid and trasylol reduce uterine bleeding in IUD users. Anti-prostaglandin agents such as mefenamic acid have also been shown to reduce the amount—but interestingly not the duration—of IUD-related bleeding. Both types of agents are now being tested for slow release from medicated devices [10].

Many questions have to be answered about safety of these new approaches before they generally applied. It is also quite possible that the slow release of some of the agents throughout the menstrual cycle might interfere with the contraceptive action of IUDs if, as has been suggested, the mechanism of action of IUDs is ultimately linked with the side effect of bleeding [10].

Drugs can be slowly released, either from the device itself or from the thread, and an interesting possibility is the use of some antiseptic agent to be released from a special thread throughout the lifetime of the device, with the aim of protecting the user from pelvic infection. If this proves feasible, it may not be necessary to devise new systems for IUD detection and removal [10].

Research continues to improve the copper-bearing devices. Their life span may be improved by the use of copper bands rather than wire or by the use of copper wire with a silver core. Application of the copper high in the fundus as with the TCu-220C may give increased effectiveness, and it appears that the addition of zinc to the Cu-7 reduces the pregnancy rate when compared with the Cu-7 [10].

Various groups are also studying the chemistry of the encrustation that is a common feature of removed copper IUDs. An interesting suggestion from the Edinburgh group, yet to be confirmed, is that many failures of copper IUDs are associated with deposits in which Sulphur predominates, among other elements, instead of calcium, the major element detected in the majority of deposits [10].

Although some aspects of IUD technology, particularly those relating to the controlled release of drugs, are so far advanced, there are large areas of ignorance. There is a need to know much more about the biochemistry and physiology

of the normal endometrium, and the events that occur adjacent to both inert and medicated IUDs during the different phases of the menstrual cycle [10].

Delta-T, a Copper-T device with biodegradable spurs developed by the International Fertility Research Program, Research Triangle Park, NC, USA, for insertion immediately after delivery of a full-term baby and placenta. The spurs, made simply from No. 2 chromic catgut, serve to retain the device during the period of uterine involution, the time of high expulsion risk. Once the sutures dissolve, the IUD is restored, unlike most previous designs, to a configuration appropriate to the nonpregnant uterus. This is the most promising approach to post placental IUD insertion at the present time [10].

6. CONCLUSION

Technical solutions to some IUD problems can be anticipated in the near future. Dealing promptly and effectively with unwanted effects is a key component to the success of any IUD program. In this paper, we have seen some advantages, disadvantages, and possible risks for both Hormonal and Non – Hormonal IUDs. By this paper, there may be some understanding on the two types of IUD devices and hence will give a lead to improved performance both of the devices available now and those to be expected in the foreseeable future.

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