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Medical Simulation w.s.r. to Yogyasutreeya

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Abstract**—***The growing emphasis on patient safety has driven healthcare professionals to adopt simulation-based training as a core component of clinical education. Simulation has become a widely accepted tool across various industries, including healthcare, to enhance the quality and safety of services. Historical evidence of medical simulation can be traced back to the Susruta Samhita, one of the oldest known texts in the field of medicine. In the Yogyasutreeya chapter of Sutrasthana, Acharya Susruta emphasized the use of readily available objects for practical training to enhance surgical dexterity. Over time, advancements in technology have significantly evolved simulation techniques, further solidifying their role in modern medical education and practice. This article focuses on detailed description and importance of yogyasutreeya and their modern correlation along with modern era medical simulation.*

Keywords**—** *Patient safety; Practical training; Simulation; Susruta Samhita; Yogyasutreeya.*

I. INTRODUCTION

One of the primary causes of medical errors is the lack of adequate practical skills among healthcare providers. Reports such as 'To Err is Human' by the Institute of Medicine in the United States have highlighted alarming statistics on mortality resulting from preventable medical errors[1]. Many patients continue to suffer from disabilities caused by such lapses in clinical care. Since ancient times, medical practitioners have sought ways to reduce risks associated with treatment. Hippocrates, regarded as the Father of Medicine, emphasized this principle with the maxim "Primum non nocere"- "First, do no harm"—underscoring the longstanding commitment to minimizing medical errors and enhancing patient safety. Historical evidence suggests that simulation techniques were employed even in ancient times to improve clinical competency. Among these, the Susruta Samhita stands out as one of the earliest and most practical references to medical simulation. With the progression of technology, simulation methods have evolved significantly, contributing to the advancement of safe and effective medical training.

Yogyasutreeya

Susruta, revered as the Father of Surgery, made monumental contributions to Ayurvedic surgical science through his seminal work, the Susruta Samhita. As a pioneering figure in surgical practice, he meticulously documented procedures for anatomical dissection, various surgical interventions, and the techniques required for their execution. Prior to performing surgeries, particularly the *Ashtavidha Shastrakarma* (eight types of surgical procedures), *Susruta* emphasized the importance of thorough preparation. This included the collection of necessary materials, detailed explanation of instrument use (*Yantra Vidhi*, *Shastra Vidhi*), and a distinct focus on hands-on training outlined in the dedicated chapter *Yogya Sutreeya*[2]. This early reference to simulation underscores its long-standing relevance in surgical education. *Susruta* advocated for comprehensive training that encompassed not only theoretical knowledge and understanding of procedural steps but also practical skill development using training objects before engaging in clinical practice. He delineated clear criteria for a student to be deemed ready for professional practice: mastery of foundational knowledge, understanding of core principles, proficiency in technical skills, practice on dummies, and the ability to teach the discipline. The use of simple and accessible objects for simulation-based training may have been influenced by the limited availability of anesthetics during his time, necessitating rapid and accurate surgical performance to minimize patient discomfort. Thus, the *Yogyasutreeya* plays a crucial role in cultivating efficiency and precision, ultimately enhancing patient safety and reducing procedural pain[3].

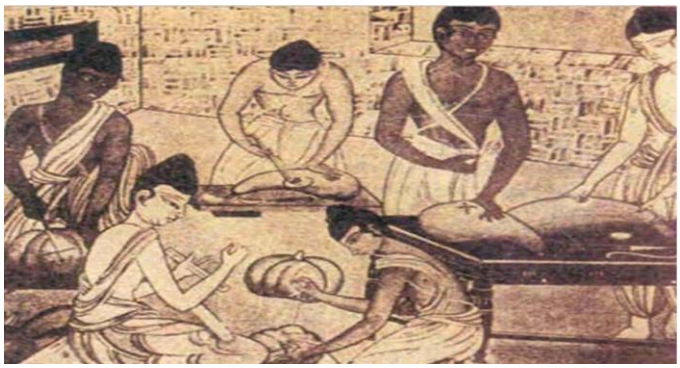

Fig.1. Susruta's disciples practicing in various yogyas

Various *karmas* with *yogyas* according to *yogyasutreeya* and current era are tabulated below.

TABLE. 1. Karmas along with their respective yogyas and present-day practices

Karma	***Yogyas***	**Current practice**
Chedana (Excision) (Utkartana, apakartana)	Pumpkin, Bittergourd, Watermelon, cucumber etc.	Rubber or silicone sheets or tubes, latex skin pad.
Bhedana (Incision)	Leather bag, urinary-bladder filled with water	Rubber or silicone sheets or tubes, latex skin pad.
Lekhana	Hairy skin	Burnt cattle skin to

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(Scraping)		resemble an eschar for wound debridement.
Vyadhana (Puncturing)	Lotus stalk, vein of dead animals.	IM injection simulator, IV arm, Spinal injection simulator.
Eshana (Probing)	Holes in moth eaten wood piece, bamboos, through the mouth of dried gourd.	Virtual reality simulators, Hybrid simulators for endoscopy, laparoscopy etc.
Aharana (Extraction)	Pulp of *bilwa*, Jack fruit, teeth of dead animals.	Dental tooth extraction model/ mannequins.
Visravana (Draining)	*Salmali* wood coated with bee wax.	Paracentesis simulator.
Seevana (Suturing)	Closely knitted cloths, borders of soft leather.	Silicone suture pads, Artificial skin.
Bandhana (Bandaging)	Mannequins prepared of mud or cloth.	Bandaging simulator with ostomy, Lower & upper stump bandaging simulator
Kshara karma (Chemical Cauterization) Agnikarma (Thermal Cauterization)	Soft muscles	Virtual reality surgical simulators – cauterization of blood vessels.
Karna sandhi-bandha (Ear suturing)	Soft skin, muscles and hollow stalk of lilly.	Silicone ear model
Vasthi (Enema), Vrana vasthi	Mouth of *alabu*, Pot having a spout at its side containing water.	Enema administration simulator

Chedana involves excising damaged body parts with a surgical knife. Techniques can be practiced on fruits like pumpkins and cucumber etc, which have firm exteriors and soft interiors, helping practiotioners learn pressure control and instrument handling in various directions for different body parts[4].

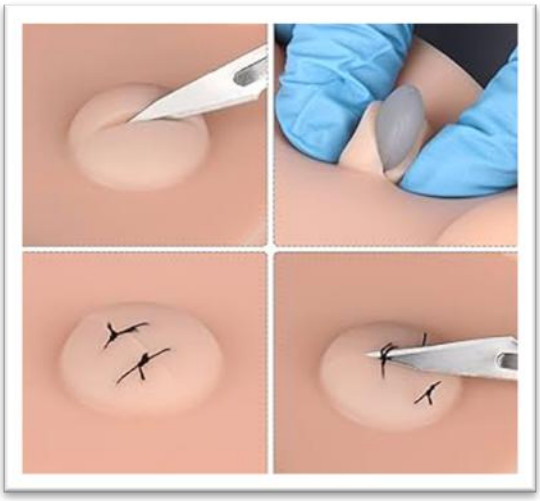

Fig. 2. Sebaceous cyst skin pad

One of the indications for *bhedana* is abscess and it is filled with fluid or pus and outer skin will be tight. Leather bag and urinary bladder filled with water resembles this. So, one can feel how much pressure should be exerted for incision and how to explore a cavity[5].

Scraping should be practised on piece of hairy animal skin which resembles human skin. Though a small surgical procedure, it teaches adequate tissue removal and protection of underlying and sidewise strutures[6]. In *indraluptha*, only minor aberrations needed while *dushtavrana* requires full debridement highlighting the difference in scraping depth for each condition.

Fig. 3. Lipoma tissue pad

Precision is mandatory for *Vyadhana karma* as improper puncturing of the sira can lead to 20 types of complications. The vein of dead animals resembles human veins, while the slippery lotus stalk makes puncturing more challenging. These *yogyas* help practitioners learn the right pressure and angle for proper puncture.

Fig. 4. I V Arm

The probing technique- *eshana karma* was practiced on moth eaten wood, bamboo, mouth of dried gourd which have multiple holes for easy passage of probe. Moth eaten wood piece correlates with sinus of *nadivrana*, canal of *bhagandara* etc., while bamboo represents external orifices. This help in learning to assess the direction, depth, distance and communications of sinuses and cavities in human body.

Aharana karma (extraction) can be practiced using *bilwa* pulp, jackfruit and dead animal teeth. Jackfruit has fibres attached to the root. At first the fibres should be removed and then separate the fruit from its root. Students can get the idea of adequate force to be exerted and where to hold during extraction without damaging nearby structures from these. The

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practice of *aharana karma* in both ripe unripe fruits will help to differentiate the extraction various kinds of tissues.

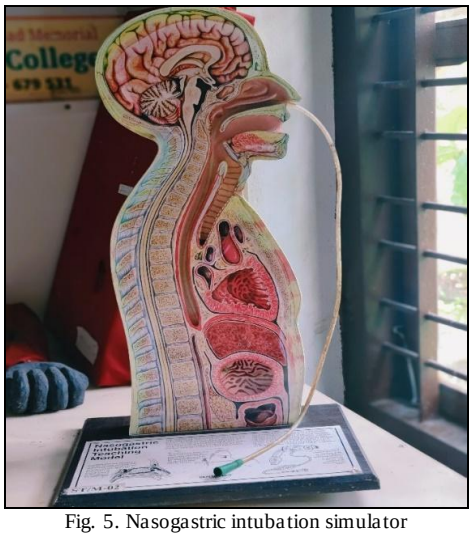

Fig. 5. Nasogastric intubation simulator

Fig. 6. Urinary catheterization simulator

Visravana karma is meant for eliminating abnormal fluid collection, was practiced on *salmali phalaka* coated with bee wax. The bark's high liquid content and the soft nature of bee wax allowed practitioners to simulate making superficial incisions and draining fluid. Although paracentesis simulators are available, research is focused on developing low-cost alternatives to enhance skills affordably[7].

Seevana training used *yogyas* like cloths (collection of threads) and soft leather borders, mimicking tissues made of collagen. This practice helps students learn suture bite size, spacing and depth. Using cloths of varying thickness simulates suturing on different body parts with varying skin thickness. These are all about *ashtavidha sastrakarma*.

Acharya has also mentioned training objects for *bandhana, kshara, agni* and *vasthi karmas* and *karna sandhibandha* along with *ashtavidha sastrakarmas*. *Bandhana karma* was studied with manniquins made up of cloth and mud. *Acharya Susruta* mentioned 14 types of *bandhana* according to site and use. Each body part is having different circumference. Each and every *bandhana* can be studied by applying it on different body parts or to the mannequin.

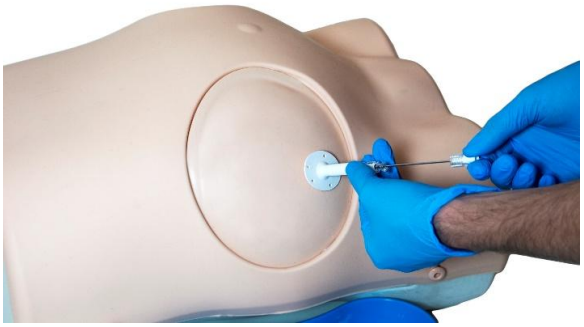

Fig. 7. Paracentesis simulator

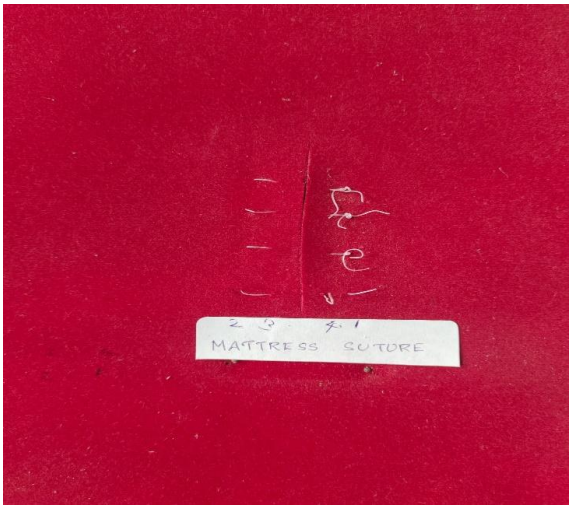

Fig. 8. Suturing practiced in cloth

Fig. 9. Bandha practised in mannequin

The best *yogya* for studying *kshara karma* and *agnikarma* is soft muscles. Students can easily observe the features of *samyak dagdha, atidagdha* and *durdagdha* in muscles. There are no simulators which is having simulation of cauteriation

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only. It can be studied as a part of surgery during usage of virtual reality surgical simulators.

Karna sandhana was practiced on *yogyas* like soft skin, muscles and hollow stalk of lilly. Ear is a delicate structure, so similar *yogyas* were utilised to study *karna sandhana*. *Susruta* is the father of plastic surgery and his notes on this have cosmetic values even in present era. So, he ensures the skill of students in *karna sandhana*.

Fig. 10. Silicone ear model

The last procedure for training mentioned in *yogyasutreeya adhyaya* is *vasthi* and *vrana vasthikarma*. It was trained on pot filled with water with a hole in its side and mouth of *alabu*. Improper *vasthikarma* can cause various *vasthivyapath*, i.e. it can cause damage to the site of application, dysentery and head ache to the patient. Practicing the insertion of *vasthi netra* into a pot's hole without spilling water and in to an alabu's mouth without widening its opening helps students develop precision in *vasthikarma*.

Yogyasutreeya has been strictly emphasised by *Susrutha* because dexterity requires the development of psychomotor competencies, a process based on regular practice. Thus, students should made to practice *snehadi* and *chedanadi karmas* even before he has thoroughly mastered the interpretations of all the scripture.

Medical Simulation

Historical evidence of simulation in medical training spans various cultures. Ancient clay and stone anatomical models have been discovered in the Middle East, Central Asia, and North Africa[8]. However, the Susruta Samhita remains the earliest written documentation of simulation techniques. In ancient China, life-sized bronze sculptures were utilized for examining anatomy and acupuncture, whereas ivory female figures were used to convey symptoms in a discreet manner. In Peru, skulls with bite marks suggest post-mortem examinations aimed at refining surgical skills. Due to restrictions on dissection, ancient Europe relied on wax and anatomical models for instruction.

The first modern medical simulator was developed in the 1700s by Gregoire and his son, who used a human pelvis and a deceased infant to train midwives, significantly reducing infant mortality. Key milestones in the contemporary era of medical simulation consist of Resusci-Anne (the most commonly used CPR mannequin of the 20th century), Sim One (the initial computer-controlled mannequin for anesthesia education), and Harvey (a cardiology simulator able to mimic various cardiac conditions). These innovations paved the way for the establishment of skill labs, beginning in the 1970s at the University of Illinois and Maastricht University, marking a turning point in the integration of simulation-based education in medical curricula worldwide.

Simulation involves the imitation of actual life situations, items, or processes, commonly utilized in medical training to improve clinical abilities. Simulation labs may include dissection halls, standardized patients, mannequins, virtual dissection tables, and robotic simulators[9]. Simulators are typically categorized by fidelity—the degree of realism they offer[10].

Low-fidelity simulators, such as CPR mannequins and partial task trainers, are static and focus on developing basic psychomotor skills. Medium-fidelity simulators include full-body mannequins with features like simulated breath, heart and bowel sounds, and artificial blood, though they lack interactive responses. An example is the Harvey cardiology simulator. High-fidelity simulators are advanced models capable of replicating physiological signs such as speech, breathing, blinking, and real-time responsiveness, closely mimicking live patients.

In recent years, virtual dissection tables have emerged as effective tools for anatomical education, especially when cadavers are unavailable. They reduce ethical concerns and health risks associated with cadaveric dissection, while providing detailed, interactive anatomical visualization.

II. Discussion

In the *Susruta Samhita Sutrasthana, Acharya Susruta* describes 101 surgical instruments (*yantras*) and 20 sharp tools (*sastras*), detailing their number, uses, shapes, sizes, and the correct methods of handling to ensure surgical precision. For example, tools employed for bhedana (incision) should be grasped between the handle and blade to maximize control. Each *sastra karma* (surgical procedure) requires specific hand movements and pressure, underscoring the importance of adhering to *Acharya Susruta's* guidelines.

Failure to use instruments correctly can result in severe complications. In the *Ashtavidha Shastra Karma* chapter, *Susruta* outlines four major surgical errors: inadequate cutting, excessive cutting, improper cutting, and self-injury—the first three jeopardize patient safety, while the last poses a risk to the surgeon. Additional complications from improper instrument use are discussed in the *Agropaharaneeya Adhyaya*, including vein and ligament injuries, intense pain, delayed wound healing, and the formation of abnormal muscular growths.

Teaching complex clinical procedures directly on patients poses ethical challenges and can increase patient anxiety. Instructing students during live procedures may also be disruptive and impractical. Simulation-based training addresses these issues by offering a safe, controlled, and fault-forgiving environment. It reduces student anxiety, fosters

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interest in clinical practice, and allows learners to build skills without the risk of harming patients. It also provides exposure to rare but critical clinical scenarios, boosting confidence and preparedness.

However, simulation has limitations. It may lack the realism and emotional engagement of real patient interactions, and students may not fully experience the side effects or complexities of live procedures. Additionally, simulations can be inflexible, with constraints on what scenarios can be replicated. High costs associated with advanced simulation technologies are another notable drawback.

The development of clinical skills is closely linked to neuroplasticity—the brain's ability to reorganize and adapt in response to learning and experience. Prolonged engagement in specific tasks can alter the distribution of grey and white matter in related brain regions. *Acharya Susruta's* placement of *Yogyasutreeya* before *Vishikhaanupraveshaneeya* in the *Susruta Samhita* suggests the importance of acquiring practical skills early in medical training.

A significant advancement in modern simulation is the integration of artificial intelligence (AI). AI simulates human intelligence, enabling the creation of realistic, adaptive virtual patient scenarios that enhance learning. It can also be used to monitor and assess student performance during simulation-based training. However, overreliance on AI may reduce critical thinking skills, and system errors can pose risks—emphasizing the need for proper safeguards.

Globally, simulation-based education has become an integral part of healthcare training[11]. While countries like the United States and Germany have embraced this approach, its adoption in India remains limited. To strengthen medical education, India must invest in centralized simulation training facilities and promote simulation-based learning across institutions.

III. Conclusion

According to *Acharya Susruta*, a surgeon must possess certain essential qualities-*Vaidya Gunas*, before undertaking surgical procedures. The *Yogyasutreeya* chapter emphasizes the development of six such attributes: *Sauryam* (courage), *Asukriya* (prompt action), *Shastra Tikshnyam* (precision with instruments), *Asveda* (absence of perspiration), *Avepathu* (steadiness), and *Asammoha* (clarity of mind). *Susruta* asserts that theoretical knowledge alone is insufficient; without practical training, even a well-read individual remains unfit for surgical or clinical practice.

To bridge this gap, students must engage in hands-on procedures, such *as Snehadi Chedanadi Karma*, even after mastering the scriptures. The *Yogyasutreeya* highlights the critical role of dexterity in minimizing clinical errors and ensuring patient safety—principles that form the foundation of both ancient and modern simulation-based training.

Similarly, *Acharya Vagbhata* in the *Ashtanga Hridaya* affirmed that therapeutic success is achieved through continuous practice. Skill development in clinical settings relies on realistic learning environments and repeated exposure. Therefore, the traditional model of "see one, do one, teach one" must evolve into "see many, do many, teach many" to ensure competence and confidence in modern medical education[12].

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