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BRIDGING TRADITION AND TECHNOLOGY: A REVIEW ON SIMULATOR-BASED LEARNING THROUGH THE LENS OF *SUŚRUTA'S YOGYA SUTRIYA ABHYĀSA*

Dr. Nihal Gopan [1], Dr. Bharathi D Anvekar [2], Dr. Parvathy S [3]
Dr. Manjunath S Naregal [4]

[1]3rd Year PG Scholar, Department of Shalya Tantra,
Sri Dharmasthala Manjunatheswara Institute of Ayurveda and Hospital, Bengaluru, Karnataka, India.
[2]Prof. and PG Dean of the Institute, Department of Shalya Tantra,
Sri Dharmasthala Manjunatheswara Institute of Ayurveda and Hospital, Bengaluru, Karnataka, India.
[3]Associate Prof., Department of Shalya Tantra,
Sri Dharmasthala Manjunatheswara Institute of Ayurveda and Hospital, Bengaluru, Karnataka, India.
[4]Assistant Prof. Department of Shalya Tantra,
Sri Dharmasthala Manjunatheswara Institute of Ayurveda and Hospital, Bengaluru, Karnataka, India.

ABSTRACT

Simulation-based education bridges the gap between traditional Ayurvedic experiential learning and modern medical pedagogy by offering a safe and controlled environment for acquiring diagnostic and procedural skills before performing them on real patients. The concept of Yogya Dravya Abhyāsa described by Āchārya Suśruta in the Yogya Sūtrīya Adhyāya of Suśruta Saṃhitā represents the earliest form of simulation training, emphasizing skill acquisition through practice on substitute materials rather than live subjects. This review explores the relevance of these classical training models – such as practice on plant stalks, animal tissues, and clay or leather models – and correlates them with modern simulation-based methodologies, including manikin-based, tissue-based, virtual reality, and standardized patient simulations. Both traditional and modern systems share the objective of enhancing precision, minimizing errors, and promoting ethical, experiential learning. Contemporary technologies like the Anatomage Table further advance these ancient principles by integrating virtual anatomy and imaging for realistic, risk-free learning. The convergence of Suśruta's scientific foresight with modern simulation models reaffirms the timeless value of hands-on education in Ayurveda, providing a strong framework for safe, effective, and ethically grounded medical practice.

KEYWORDS: *Simulators, Yogya, Yogyasutriya, Suśruta Saṃhitā, Surgical training, Anatomage table, Virtual reality.*

INTRODUCTION

Simulation has emerged as an innovative educational approach that provides an artificial yet realistic representation of real-world clinical scenarios to achieve specific learning goals through experiential methods [1-2]. In medical education, simulation-based training has evolved as a vital tool to enhance skill acquisition, confidence, and decision-making in a risk-free environment [3]. The roots of simulation training trace back to the early twentieth century when anaesthesia physicians first employed it to minimise procedural errors. Its rapid growth began in the 1930s with the development of mechanical and flight simulators, which inspired the adaptation of simulation for healthcare training [4-5]. Although initially met with hesitation due to technological limitations and scarcity of expert trainers, the concept gained acceptance as advancements in computer technology enabled realistic virtual experiences by the 1980s [6]. The establishment of the Society for Simulation in Healthcare (SSH) in 2004 marked a significant milestone in uniting professionals worldwide to advance medical simulation standards and research [11].

Interestingly, the concept of simulation-based learning is not new to the world of medicine. The foundation of practical medical education through simulation was laid centuries ago in ancient India by **Acharya Sushruta**, often revered as the *Father of Indian Surgery* [7-9]. Around 300 B.C., Sushruta emphasised the importance of hands-on training before operating on human subjects. In his monumental work, the *Sushruta Samhita*, he dedicated an entire chapter titled *Yogyasutriya Adhyaya* (Sutrasthana, Chapter 9) to guide surgical trainees. He advocated practising various surgical and para-surgical techniques such as *Astavidha Shastra Karma* (eight surgical procedures) and *Bandhana Karma* (bandaging techniques) on natural substitutes like fruits, vegetables, leather bags, and animal tissues—an early and highly sophisticated form of simulation [10].

The principles proposed by Sushruta continue to hold relevance even in modern times, aligning seamlessly with today's simulation-based medical education. His emphasis on practice, precision, and progressive learning reflects an understanding of experiential pedagogy that remains unmatched. Thus, while modern simulation employs advanced mannequins and digital models, the philosophical foundation of learning through artificial yet realistic practice can be traced back to Ayurveda's ancient surgical wisdom. This review aims to explore the evolution, application, and relevance of simulation-based

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education in Ayurveda, highlighting how ancient teachings continue to inspire modern medical training methodologies.

Why Simulation?

The ancient proverb, *"I hear, I forget; I see, I remember; I do, I learn,"* beautifully encapsulates the essence of experiential learning—a principle that underpins simulation-based education. Learning through experience allows deeper intellectual comprehension by transforming abstract concepts into tangible skills [12]. According to **Kolb's Experiential Learning Theory (1984)**, true knowledge results from the combination of grasping and transforming experience through active engagement and reflection [13]. Similarly, Mezirow and Freire emphasised that the heart of learning lies in critical reflection on experience, which converts passive information into meaningful understanding [14-15]. Simulation aligns seamlessly with these pedagogical philosophies by offering a safe, controlled, and repeatable environment where learners can translate theoretical knowledge into practice. It provides opportunities to make decisions, perform actions, and witness consequences—without endangering real patients or systems. As Smith (1999) observed, simulations enable learners to explore the outcomes of their choices without bearing the real-world risks, thereby fostering confidence, competence, and clinical reasoning [16]. Hence, simulation serves as a dynamic bridge between theory and practice, promoting active participation, retention, and mastery in medical and Ayurvedic education alike.

Surgical Simulation

Over the last three decades, surgical simulation has emerged as a pivotal tool in medical education, offering an immersive and standardized means of acquiring technical competence while ensuring patient safety. Simulation-based training provides a realistic and controlled environment that enables learners to refine their psychomotor abilities, hand–eye coordination, and confidence in performing complex or rare procedures without risk to patients [17-18]. With the advancement of minimally invasive and laparoscopic techniques, simulation has become integral to surgical education, as skills acquired in simulated settings have been shown to translate effectively to real clinical performance [19]. It also allows experienced surgeons to learn novel and high-precision procedures such as facial transplantation through cadaveric simulations [20].

The philosophical foundation of surgical simulation, however, finds its earliest and most profound expression in the Ayurvedic tradition, particularly in the teachings of *Acharya Sushruta*, the revered *Father of Indian Surgery*. In the *Yogyasutriya Adhyaya* of the *Sushruta Samhita*, Sushruta elaborated a comprehensive system of surgical training that mirrors modern simulation-based education. He emphasised that theoretical understanding must be reinforced by practical application on non-living models before attempting surgery on living beings. This principle is encapsulated in the verse — ***"अधिगतसर्वशास्त्रार्थमपि शिष्यं योग्यां कारयेत्, स्नेहादिषु छेद्यादिषु च कर्मपथमुपदिशेत्, सुबहुश्रुतोऽप्यकृतयोग्यः कर्मस्वयोग्यो भवति"*** (*Su. Su. 4/9*), which asserts that even a student well-versed in all theoretical sciences must be made *Yogya* through practical training; one who is extensively learned but has not undergone such practice is unfit to perform surgery [21-22].

Further, *Dalhana* explains the concept of *Yogya* as ***"योग्या सम्यक्कर्माभ्यासः, योग्यायाः सूत्रं, तद्विद्यते यस्मिन् स"***, meaning one becomes *Yogya* through correct and consistent practice of surgical methods [23]. Sushruta emphasized that the mere study of scriptures is insufficient unless accompanied by repeated exercises in techniques like *Sneha*, *Chedana*, *Bhedana*, and others, as reiterated in ***"कुतोऽधिगतसर्वशास्त्रार्थमपि शिष्यं योग्यां कारयेदित्याह–सुबहुश्रुतोऽपीत्यादि"***, stressing the indispensable role of experiential training [24].

Sushruta also described *Aṣṭavidha Śastra Karma* — the eight categories of surgical procedures, namely *Chedana* (excision), *Bhedana* (incision and exploration), *Lekhana* (scraping), *Vyadhana* (puncturing), *Eshana* (probing), *Aharana* (extraction), *Visravan* (drainage), and *Sivana* (suturing), along with procedures like *Kshara Karma* (application of alkalis), *Agni Karma* (cauterisation), and *Bandhana Karma* (bandaging) [25]. These ancient surgical techniques were to be mastered first through simulation on non-living materials such as gourds, animal skins, or plant stems that mimic human tissues, before being performed on live patients — a method identical in spirit to today's concept of simulation-based skill acquisition.

Thus, *Acharya Sushruta*'s teachings represent the earliest codified model of experiential learning in surgery. His emphasis on repetitive, safe, and ethical practice aligns seamlessly with modern educational frameworks such as Kolb's experiential learning cycle and the simulation-based competency approach. By integrating ancient wisdom with present-day educational technologies, surgical simulation embodies the timeless Ayurvedic philosophy that true mastery arises from *Anubhava* (experience) rather than *Śruti* (theory) alone, reinforcing the continuity of India's contributions to global surgical education.

1. *Chedana Karma* (Excision Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, *Āchārya Suśruta* advises practical training for *Chedana Karma* (excision) on suitable substitutes to develop precision and control. He states:

"तत्र पुष्पफलालाबूकालिन्दकत्रपुसै(सो)र्वारुककर्कारुकप्रभृतिषु छेद्यविशेषान् दर्शयेत्, उत्कर्तनापकर्तनानि चोपदिशेत्।" (*Su. Su. 4/9*)

Different kinds of excision should be demonstrated on materials such as Puṣpa-phala (flower fruit), Ālābu (bottle gourd), Kālindaka (melon), Trapusa (cucumber), Ervaruka (watermelon), and Karkaruka (bitter gourd), so that the student learns to avoid excessive (Utkartana) or inadequate cutting (Apakartana).

Chedana Karma involves practising surgical excision on substitutes like bottle gourd or melon to develop precision, depth control, and tactile skill—an ancient form of simulation reflecting Suśruta's emphasis on safe, hands-on surgical training.

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2. *Bhedana Karma* (Incision and Exploration Simulation)
In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, *Āchārya Suśruta* describes practical training for *Bhedana Karma*—the act of incision and exploration. He instructs:
"दतिबस्तिप्रसेवकप्रभृतिषूदकपङ्कपूर्णेषु भेद्ययोग्यां।" (*Su. Su. 4/9*)
Bhedana, or the act of incision and division, should be practised on objects such as druti (bellows), basti (animal bladder), prasevaka (leather sac), and similar materials filled with water or mud. This allows the practitioner to experience the realistic resistance and turgidity encountered during surgical incision.

This simulation mirrors the tension and pressure of abscesses (*Pakva Vidradhi*), training surgeons in depth control and precision for managing deep or superficial abscesses and fistulous tracts, reflecting Suśruta's scientific foresight in surgical simulation.





3. *Lekhana Karma* (Scraping Simulation)
In the Yogyasūtrīya Adhyāya of *Suśruta Saṃhitā*, Āchārya Suśruta describes practical training for Lekhana Karma—the procedure of scraping and removing unwanted tissues. He instructs:

"सरोम्णि चर्मण्यातते लेख्यस्य;" (Su. Su. 4/9)

Lekhana, or scraping, should be practised on a part of the skin covered with fine hair (saroṃṇi carmaṇi), to develop control over the depth and direction of scraping without damaging the underlying healthy tissues.
This simulation replicates the sensitivity and tactile feedback required for removing hypergranulation, keratinized tissue, or sequestrum. It cultivates precision and judgment in wound management, demonstrating *Suśruta's* advanced understanding of experiential learning in surgical practice





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4. *Vyadhana Karma* (Puncturing Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta describes practical training for Vedhana Karma—the act of puncturing or perforation. He instructs:

"मृतपशुसिरासूत्पलनालेषु च वेध्यस्य;" (Su. Su. 4/9)

Vedhana, or puncturing, should be practised on the veins of a dead animal (mṛta-pashu-sirā) and lotus stalks (utpala-nāla), which are smooth and spongy in nature, to cultivate precision and control in penetrating delicate tubular structures. This simulation replicates the tactile resistance encountered during procedures such as venepuncture or abdominal paracentesis, refining the surgeon's skill in controlled depth and angle of insertion, exemplifying *Suśruta's* foresight in hands-on surgical training.





5. *Eshana Karma* (Probing Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta elaborates the training method for Eshana Karma—the act of probing or exploring cavities. He instructs:

"घुणोपहतकाष्ठवेणुनलनालीशुष्कालाबूमुखेष्वेष्यस्य;" (Su. Su. 4/9)

Eshana, or probing, should be practised on wood perforated by worms (ghuṇopahata kāṣṭha), bamboo, hollow reeds (veṇu-nāla), and dried gourds (śuṣka ālābu), which contain multiple channels and cavities. This exercise trains the practitioner to navigate tortuous pathways smoothly and without causing damage.

The simulation enhances tactile sensitivity and spatial awareness, enabling the learner to explore sinus tracts and internal cavities safely—an early analogue to modern diagnostic probing techniques, reflecting *Suśruta's* profound insight into surgical skill development.





6. *Aharana Karma* (Extraction Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta explains the method of *Aharana Karma*—the act of extracting or removing foreign bodies. He instructs:

"पनसबिम्बीबिल्वफलमज्जमृतपशुदन्तेष्वाहार्यस्य;" (Su. Su. 4/9)

Aharana, or extraction, should be practised on objects such as the pulp of jackfruit (panasa), bilva fruit (bilva-phala), and the teeth of a dead animal (mṛta-pashu-danta), which provide realistic resistance similar to impacted materials in the body. This training enables the practitioner to master the technique of grasping, dislodging, and removing embedded objects safely. The simulation cultivates controlled traction and precision, essential for procedures like the removal of foreign bodies, stones, or faecoliths—demonstrating *Suśruta's* scientific foresight in experiential surgical education.

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7. *Visrāvana Karma* (Drainage Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta describes the practice of Visrāvana Karma—the technique of draining accumulated fluids or vitiated blood. He instructs:

"*मधूच्छिष्टोपलिप्ते शाल्मलीफलके विस्राव्यस्य;*" *(Su. Su. 4/9)*

Visrāvana, or drainage, should be practised on a piece of Śālmalī wood coated with beeswax (madhūcchiṣṭa). The beeswax provides a soft, pliable surface resembling human skin, while the fluid content within Śālmalī bark mimics natural body fluids. This enables the learner to understand the pressure, angle, and depth required for effective incision and controlled drainage.

The simulation fosters precision in releasing accumulated fluids and recognizing pathological conditions like *rakta duṣṭi* (vitiation of blood), reflecting *Suśruta's* advanced comprehension of surgical physiology and his systematic approach to hands-on medical training.





8. *Sīvana Karma* (Suturing Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta illustrates practical training for Sīvana Karma—the art of suturing and wound edge approximation. He instructs:

"सूक्ष्मघनवस्त्रान्तयोर्मृदुचर्मान्तयोश्च सीव्यस्य;" (Su. Su. 4/9)

Sīvana, or suturing, should be practised on the edges of fine, densely woven cloth (sūkṣma ghana vastra) and on the margins of soft leather (mṛdu carma). These materials closely replicate the texture, elasticity, and resistance of human skin, allowing the student to learn the correct technique of approximating wound edges without tension.

This simulation develops precision in hand movements, knot security, and tissue handling—skills crucial for surgical wound closure. It reflects *Suśruta's* deep anatomical understanding and his foresight in creating structured, safe, and realistic training models for surgical competence

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9. *Bandhana Karma* (Bandaging Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta elaborates on Bandhana Karma—the science of bandaging and immobilization. He instructs:

"पुस्तमयपुरुषाङ्गप्रत्यङ्गविशेषेषु बन्धनयोग्यां;" (Su. Su. 4/9)

Bandhana, or bandaging, should be practised on specific parts and subparts of dummies made of cloth (pustamaya puruṣa). Āchārya Suśruta describes fourteen types of Bandhanas to be applied according to the disease condition and seasonal variations. Proper bandaging not only aids in the healing of lacerated and crushed wounds but also provides support in cases of dislocation and fracture, ensuring comfort in movement, sitting, and resting.

This simulation helps learners understand pressure distribution, joint stabilization, and the balance between firmness and comfort—principles that mirror modern orthopaedic and surgical dressing techniques. It reflects *Suśruta's* methodical and patient-centric approach to postoperative care and rehabilitation through experiential learning.



10. *Agni* and *Kṣāra Karma* (Cauterization and Alkaline Application Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta describes practical training for Agni and Kṣāra Karma—two vital *para-surgical* procedures in Ayurveda. He instructs:

"मृदुषु मांसखण्डेष्वग्निक्षारयोग्यां;" (Su. Su. 4/9)

Agni Karma (thermal cauterization) and Kṣāra Karma (alkaline cauterization) should be practised on soft muscle tissue (mṛdu māṃsa khaṇḍa), as it closely resembles human tissue response. Practising on such models allows the student to observe the Samyak Dagdha Lakṣaṇas (signs of proper cauterization), including color change, tissue contraction, and healing patterns.

This simulation enhances the learner's understanding of heat intensity, depth control, and tissue reaction—core parameters for safe and effective therapeutic cauterization. It exemplifies *Suśruta's* scientific insight into replicating physiological responses for skill acquisition, anticipating modern surgical simulation in controlled settings.





11. *Karṇa Sandhi Bandhana* (Ear Reconstruction and Bandaging Simulation)

In the *Yogyasūtrīya Adhyāya* of *Suśruta Saṃhitā*, Āchārya Suśruta delineates the method for practising *Karṇa Sandhi Bandhana*—the art of repairing and bandaging the ear joint. He instructs:

"मृदुचर्ममांसपेशीषूत्पलनालेषु च कर्णसन्धिबन्धयोग्याम्;" (Su. Su. 4/9)

Karṇa Sandhi Bandhana, or the joining and dressing of a torn or separated ear, should be practised on soft skin (mṛdu carma), muscle tissue (māṃsa peśī), and the hollow stalk of a lotus or lily plant (utpala nāla). These materials provide realistic pliability and flexibility, closely imitating the delicate structure of the human ear.

This simulation helps learners develop precision in tissue approximation, fine suturing, and supportive bandaging techniques required for reconstructive procedures. It demonstrates *Suśruta's* profound anatomical understanding and his pioneering contribution to reconstructive surgery training through practical simulation-based methods.

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12. *Basti, Vraṇa-Prakṣālana* and Advanced Simulation Practices

In the *Yogyasūtrīya Adhyāya* of the *Suśruta Saṃhitā*, Āchārya Suśruta provides an elaborate description of simulation-based learning even for advanced procedures like *Basti Karma* (enema therapy) and *Vraṇa-Prakṣālana* (wound cleaning and irrigation). He instructs that these procedures should be practised on objects such as the side openings of an earthen pot filled with water or the mouth of a gourd (*lābūmukha*), as mentioned in the verse — *"उदकपूर्णघटपार्श्वस्रोतस्यलाबूमुखादिषु च नेत्रप्रणिधानबस्तिव्रणबस्तिपीडनयोग्यामिति" (Su. Su. 4/9).* These models simulate the internal pressure, flow resistance, and cavity dynamics encountered in clinical practice, allowing students to refine their precision, control, and technique without harm to living beings.

Further, Suśruta emphasizes the role of intelligent adaptation in surgical training, stating — *"एवमादिषु मेधावी योग्यार्हेषु यथाविधि। द्रव्येषु योग्यां कुर्वाणो न प्रमुह्यति कर्मसु॥" (Su. Su. 5/9*), meaning that a wise practitioner should select suitable materials resembling human tissue to gain practical proficiency in various procedures. He continues — *"तस्मात् कौशलमन्विच्छन् शस्त्रक्षाराग्निकर्मसु। यस्य यत्रेह साधर्म्यं तत्र योग्यां समाचरेत्॥"* (*Su. Su. 6/9*), highlighting that one aspiring for excellence in *Śastra Karma*, *Kṣāra Karma*, and *Agni Karma* must practice on comparable objects before performing on live patients.

TYPES OF SIMULATION IN MEDICAL EDUCATION

1. Manikin-Based Simulation

Manikin-based simulation is one of the most widely utilised forms of clinical skills training. It employs life-sized computer-based models that reproduce human anatomy and physiology to simulate realistic clinical scenarios.[26] These high-fidelity manikins are capable of exhibiting vital signs such as respiration, pulse, and heart sounds, allowing healthcare professionals to practice diagnostic methods and procedural techniques in a risk-free environment. This approach provides clinicians with hands-on experience, enhances clinical decision-making skills, and eliminates potential harm to actual patients.[26] Manikin-based simulations are essential for developing team coordination, emergency management, and technical competency in procedures such as airway management, resuscitation, and surgical interventions.





2. Skills-Training Simulation

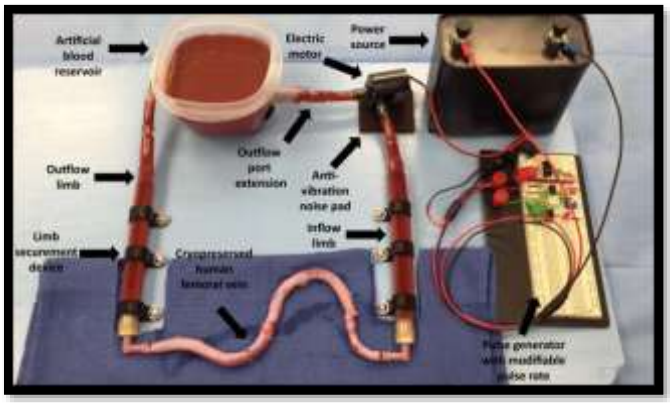
Skills-training simulation focuses on repetitive practice of specific clinical procedures and psychomotor tasks through low-fidelity or task-specific models.[27] This approach allows learners to develop and refine core competencies such as suturing, dissection, venipuncture, and pattern cutting in a controlled, non-threatening environment. It enables trainees to improve visual, tactile, and coordination skills through trial and error before transitioning to real-life clinical practice. Historically, this method of experiential learning has been employed in industries such as aviation and the military, and its integration into healthcare education has transformed how students and residents master complex technical procedures including endovascular surgery and trauma care. [27]

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3. Tissue-Based Simulation

Tissue-based simulation represents an advanced stage of training wherein learners practice on natural or synthetic tissues that closely mimic the texture and resistance of living human or animal tissues.[28] As learners progress from dry-lab task trainers to wet-lab settings, they encounter a graduated level of complexity that bridges the gap between artificial and clinical environments. This model allows procedural refinement, such as surgical dissection, suturing, and hemostasis control, under near-realistic conditions. The method ensures that learners achieve proficiency and confidence while maintaining patient safety and the highest standards of clinical care.[28]





4. Virtual Reality Simulation

Virtual reality (VR) simulation introduces an immersive and interactive three-dimensional learning environment that replicates real-life medical and surgical situations.[29] Through the use of head-mounted displays and haptic feedback devices, learners can engage in realistic simulations that allow them to visualise anatomy, navigate surgical fields, and perform virtual procedures. VR simulation provides measurable performance metrics, allows repetitive practice, and offers scalability across multiple learners without material constraints.[29] It serves as an effective educational bridge for training in minimally invasive and robotic surgical techniques, enhancing spatial awareness and hand-eye coordination.





5. Standardised Patient Simulation

Standardised Patient (SP) Simulation employs trained individuals who act as real patients with specific medical conditions in a consistent and repeatable manner. [30] This human-based simulation provides learners with opportunities to practice clinical communication, patient examination, history-

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taking, and interpersonal skills in a safe and structured learning environment. It enhances clinical reasoning, empathy, and professionalism by allowing the trainee to experience realistic patient interactions and receive direct feedback on performance. This method integrates both technical and affective learning domains, aligning with the holistic approach of medical and AYUSH systems of education.





TYPES OF EXPERIMENTAL MODELS IN MEDICAL TRAINING [31]

The evolution of experimental models has been central to developing hands-on competency in surgical and clinical disciplines. These models are broadly classified as **non-living** and **living**, each offering distinct educational value.

A. Non-Living Models

(i) Cadaveric or Synthetic Models

Cadaveric training provides irreplaceable exposure to true anatomical structures, spatial relationships, and tissue handling. Synthetic models, on the other hand, offer reproducible anatomy without ethical or preservation limitations. Both play a vital role in developing surgical dexterity before live patient exposure.

(ii) Computer Simulation

Computer-based simulations utilize software platforms to model physiological responses, procedural steps, and clinical scenarios. They serve as effective tools for decision-making, diagnostic reasoning, and procedural rehearsals with built-in feedback mechanisms.

B. Living Models

(i) Animal and Plant Models

Historically, experimental training in Ayurveda and modern medical sciences has utilised animal and plant models for developing precision in surgical skills such as incision, probing, bandaging, and cauterisation. These natural substitutes offer a safe platform for practising parasurgical techniques described by *Ācārya Suśruta*, ensuring ethical progression toward human application.

C. Anatomage Table – The Virtual Dissection System

The Anatomage Table represents one of the most technologically advanced anatomy visualisation systems currently used in medical and AYUSH institutions worldwide. It functions both as a virtual library of human and animal cadavers and as a clinical diagnostic tool capable of visualising radiological data such as CT and MRI scans in three dimensions. The system enables virtual dissection, anatomical exploration, and integration of clinical imaging for a comprehensive understanding of structural relationships. Featured in TED Talks, PBS, and Fuji TV, the Anatomage Table exemplifies the convergence of anatomy education, digital innovation, and simulation technology in modern healthcare training.



DISCUSSION

Simulation-based education bridges traditional Ayurvedic training and modern medical pedagogy by providing a safe, controlled environment to practice diagnostic and procedural skills before performing them on real patients. Ayurveda has long emphasised experiential learning (*Anubhava*) and hands-

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on training. Acharya Sushruta, through verses such as *"मृदुषु मांसखण्डेष्वग्निक्षारयोग्यां"* and *"मृदुचर्ममांसपेशीषूत्पलनालेषु च कर्णसन्धिबन्धयोग्याम्"*, advocated practice on substitute materials like soft muscle tissue and plant stalks—principles that align with modern simulation-based methods.

Simulation models used in medical education include several types. Manikin-based simulation enables performance of diagnostic and procedural skills on life-like computer-controlled models, offering realistic clinical experiences without patient risk. Skills-training simulation focuses on developing precision through repetition in a controlled setting, ranging from basic skills like venipuncture and suturing to advanced tasks such as endovascular and trauma procedures. Tissue-based simulation introduces real or biological materials to provide lifelike texture and resistance, helping learners refine techniques outside clinical environments while ensuring patient safety.
Virtual reality (VR) simulation creates immersive 3D environments that enhance anatomical understanding, procedural planning, and decision-making. Standardized patient simulation employs trained individuals to portray medical conditions, allowing learners to practice communication, examination, and clinical reasoning in realistic but safe contexts.

Experimental models are classified as non-living (cadaveric, synthetic, or computer-based) and living (animal or plant-based). These models facilitate anatomical, physiological, and procedural understanding consistent with the Ayurvedic concept of *Prayoga Sharira* (experimental anatomy). Among modern tools, the Anatomage Table stands out as an advanced anatomy visualization system combining virtual cadaveric libraries with CT and MRI scan integration. It offers detailed, ethical, and interactive 3D visualization and is widely adopted in leading medical institutions.

Thus, simulation-based learning in Ayurveda modernizes Sushruta's ancient surgical pedagogy by merging traditional hands-on methods with technological innovation, fostering precision, ethical practice, and patient safety in contemporary Ayurvedic education.

CONCLUSION

Simulation-based learning serves as a modern extension of Sushruta's ancient experiential training methods, reinforcing the timeless relevance of hands-on practice in Ayurveda. By integrating traditional models of surgical skill development with contemporary simulation technologies—such as manikins, virtual reality, and anatomage systems—Ayurvedic education can enhance precision, confidence, and ethical competence among learners. This approach ensures patient safety while preserving the essence of *Shastra Karma* training, making it a vital bridge between classical wisdom and modern medical pedagogy.

Future Scope

Integration of structured simulation modules within Ayurvedic surgical education can standardize practical skill acquisition and improve procedural outcomes. Development of indigenous Ayurvedic simulation models inspired by Suśruta's *Yogya Dravya* concept can enhance authenticity and accessibility in training. Collaborative research with modern institutions may further validate and refine these traditional simulation approaches for global relevance.

Recommendations

- Incorporate simulation-based modules in *Śalya Tantra* and *Kāyachikitsa* curricula across AYUSH institutions.
- Develop cost-effective, anatomically relevant models rooted in classical Ayurvedic descriptions.
- Encourage interdisciplinary research and faculty training in simulation pedagogy.
- Establish skill laboratories aligned with both Ayurvedic philosophy and modern safety standards.

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