

SHORT REVIEW A R T I C L E

Unlocking the Advantages Of N-Vinyl-2-Pyrrolidone as A Superior Alternative to Formalin in Cadaver Preservation: A Comprehensive Review

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1 Introduction

A cadaver is a deceased human body utilized in scientific or medical studies. The word 'dissect' originates from the Latin word 'dissecare' meaning 'to cut apart' or 'to divide into pieces' [1] for studying human anatomy, donated or unclaimed deceased individuals received by the department of anatomy contribute significantly to gross anatomy education. [2] Optimal preservation of cadavers to prevent decomposition is a critical factor in using human bodies in educational settings [3].

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Abstract

Background The field of anatomical preservation has witnessed a continual evolution of embalming techniques, with an increasing focus on exploring alternative methods that address both structural integrity and safety concerns.

Purpose This research endeavours to delve into the diverse landscape of alternative embalming method N-vinyl-2-pyrrolidone (NVP) embalming, emphasizing the need for a thorough evaluation of various factors to determine their suitability for application in educational and research institutions.

Keywords: Formalin; Embalming; N-Vinyl-2-Pyrrolidone.

1.1 Formalin

based embalming fluid has historically served as the cadaver preservation standard in anatomical education and research, with its origins tracing back to the early 20th century. Formalin's effectiveness as a fixative and preservative can be credited to its capacity to cross-link proteins, which effectively interrupts cellular processes and hinders decomposition [4]. In spite of its extensive use and effectiveness, formalin comes with several disadvantages. Its strong and unpleasant odor can be distracting for students and faculty during dissection. Additionally, exposure to formalin has been associated with different health hazards, which can vary based on the intensity and duration of exposure. Acute exposure may result in respiratory and

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irritated skin and sensitization, potentially leading to allergic reactions. Prolonged exposure to formalin has been associated with increasingly severe health implications, including neurological disorders and cancer. Formaldehyde, the primary component of formalin, is a recognized human carcinogen. Studies have shown an elevated risk of nasopharyngeal and sinonasal cancers, as well as leukemia, among individuals exposed to high levels of formaldehyde [5,6]. Besides the associated health risks, the utilization of formalin also gives rise to environmental apprehensions.

Disposing of waste contaminated with formalin can result in soil and water pollution which can have adverse effects on ecosystems and potential repercussions for human health [7]. The preservation and upkeep of cadavers are vital for teaching gross anatomy to students in medical disciplines, demanding specimens free from infections and with minimal mitogenic materials [8]. Moreover, as the need for surgical training continues to increase, there has been a recognition that formalin-based cadavers used as training models do not accurately replicate the handling experience. They are considered unsuitable due to the significant alterations in the strength, colour, and fragility of organs and tissues [9,10].

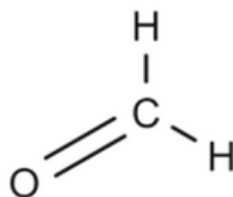


Figure 1: Structure of Formalin [11].

In this review, we will provide a comprehensive account of the N-Vinyl-2-Pyrrolidone (NVP) embalming method, detailed exploration of its advantages and drawbacks as a substitute for preserving cadavers and specimens. This review aims to support anatomy educators and embalmers in reevaluating their traditional embalming practices, with the goal of safeguarding both themselves and their students from recurrent exposure to harmful chemicals.

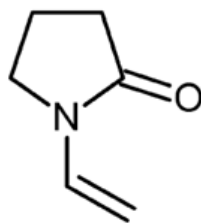


Figure 2: Structure of N-Vinyl-2-Pyrrolidone [12].

2 Methodology

This article seeks to provide an overview of the readily available chemical NVP used in the embalming of cadavers. Inclusion and exclusion criteria for this study comprised English articles, including original research, reviews, case series, and case reports, whether published or in preprint form, that documented the application of NVP for embalming cadavers in educational or research contexts. Articles lacking complete information, full-text accessibility, or pertinent data, as well as other article types such as letters, comments, and news reports, were excluded from the analysis.

Since our study was a comprehensive review of existing literature, which exclusively involved published information and did not entail any direct interaction with human subjects, it did not require Institutional Ethical Committee approval or informed consent.

3 Discussion

The chemical NVP is an organic compound characterized by a five-membered lactam ring and a vinyl group. The 'preserve' solution, containing 100% NVP and 0.1% N,N'-dibutyl-phenylenediamine, was diluted to achieve NVP concentrations equivalent to 10% of the body weight. After the infusion was complete, the arteries were ligated, and the cadaver was immersed in 5 liters of a 5% 'Preserve' solution in a sealed plastic bag, preserving it at 4°C. The endoscopic transnasal skull base approach demonstrated success in dissecting cadavers embalmed with NVP, providing a surgical field that closely resembled realistic conditions. However, NVP has its drawbacks. As the NVP concentration increases, tissue flexibility decreases, and even at the maximum concentration of 20%, the brain tissue remains too soft for dissection [12].

Furthermore, a separate study demonstrated that cadavers preserved with NVP displayed a wider range of motion compared to those embalmed with formalin. Beneath the dermis, there was a significant reduction in subcutaneous fat, and the connective tissues became translucent, enabling clear visualization of veins, cutaneous nerves, and ligaments. Internally, the organs and abdominal wall retained their suppleness and malleability, resembling those of recently deceased individuals. N-vinyl-2-pyrrolidone not only serves as a fixative but also exhibits bactericidal and preservation properties. Notably, it is devoid of formalin and eliminates the need for costly ventilation equipment. The use of NVP extended the preservation period to up to 11 months [13].

In a separate study, it was found that cadavers embalmed with NVP allowed for regular vibrations of the vocal folds, using NVP-embalmed larynges, which led

to the successful production of voiced sounds during experimental phonation [14].

Utilizing intravascular infusion of NVP-based embalming fluids can yield a cadaver that is flexible and softly fixed, with minimal microbial activity [13, 15]. NVP penetrates the body's cells, displacing water, which leads to tissue fixation through polymerization into its macromolecule PVP, and it facilitates cross-link formation through the use of free radicals [13, 15]. While the NEC maintains its flexibility (dependent on the NVP concentration) and preserves its color, it has been observed that the connective and subcutaneous lipid tissues become translucent, possibly due to lipolysis [13]. This property can aid in distinguishing between structures that appear similar, but it does not accurately reflect the appearance of in vivo anatomy. Additionally, the keratinous dermal layers of the NEC often exhibit peeling [12, 14], resembling the 'skin slip' of a decomposing corpse. Moreover, although the NEC doesn't contain formalin, it's important to note that NVP has the potential to cause mild irritation to the eyes, skin, and airways, and may even lead to severe eye damage [15]. Hence, it is imperative to provide suitable personal protective equipment to all students and staff. Nonetheless, there are several advantages to NVP embalming solutions, including the absence of the need for specialized equipment and the achievement of gentle tissue fixation. Unfortunately, information regarding the processing costs of an NEC remains elusive [13].

4 Conclusion

When deciding on a suitable alternative embalming method, it is crucial to take into account the unique requirements and limitations of individual institutions. Factors like cost, availability, infrastructure prerequisites, and the desired level of preservation quality should be carefully considered to ensure that the chosen method aligns with the educational and research objectives. Regardless of their chemical composition, ideal embalming solutions should ensure lasting structural preservation of organs, avoid excessive hardening, and maintain the color of tissues and organs. Additionally, they should effectively prevent desiccation, as well as the growth of bacteria or fungi, while also minimizing environmental exposure to hazardous chemicals and potential biohazards.

Conflict of Interest: No conflicts of interest exist between the authors and the publication of this work.

Ethical consideration: The ethical committee approved the study at Ananta Institute of Medical Sciences and Research Centre Rajsamand, Rajasthan, India.

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