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A pilot study for evaluation of knowledge and common practises of nursing staff regarding use of multidose injection vials and their microbial contamination rate in a super-specialty hospital

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Abstract:

CONTEXT: Multidose injection vials (MDVs) are prone to bacterial contamination, and their use has been reported to be a potential source of infections.

AIMS: The aim of this study was to evaluate the knowledge and common practises of nursing staff regarding the use of MDVs and its microbial contamination rate.

SETTINGS AND DESIGN: A pilot study was conducted in a super-specialty hospital from June to December 2016.

SUBJECTS AND METHODS: Information about knowledge and common practises of 100 nursing staff posted in various Intensive Care Units (ICUs) with respect to the usage of single and MDVs, respectively, was obtained and assessed. About 40 in-use multidose injection vials containing some remnants were collected from different ICUs. The volume of 1 ml content of each of these vials was inoculated into a tube containing 15 ml thioglycolate broth and incubated at 37°C for 10 days. The broth was visually examined every day and subcultured onto blood, chocolate, and Sabouraud Dextrose agar plates on alternate days within 10 days or any time that the appearance seemed turbid. The microbial isolates thus obtained were identified using standard guidelines and recorded.

STATISTICAL ANALYSIS USED: Descriptive statistics were used.

RESULTS: The study group members had sufficient knowledge about various aspects of handling single and MDVs, respectively, such as hand hygiene, disinfection, checking of vial labels, and expiry date. Low hand hygiene compliance rate of 55% was observed in all ICUs visited during this study. The contamination rate of MDVs injection vials was 25% with Coagulase-negative *Staphylococcus* spp. being the most common isolate.

CONCLUSIONS: The use of MDVs is associated with the risk of contamination and nosocomial outbreaks of life-threatening bloodstream infections. Healthcare professionals must strictly adhere to basic infection control practises as per standard guidelines to minimize the incidence of hospital-acquired infections.

Keywords:

Microbial contamination, multidose injection vials, nursing staff

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Introduction

Approximately 30%–50% of hospitalized patients require parenteral administration of drugs which are usually given out in single- and multiple-dose vials, respectively.^[1] A multidose injection vial (MDV) is a vial of liquid medication intended for parenteral administration (injection or infusion) that contains more than one dose of medication. These vials are labeled as such by the manufacturer and typically contain antimicrobial preservatives such as benzyl alcohol, benzethonium chloride, methylparaben, propylparaben, and metabisulphite to prevent bacterial growth. However, these preservatives do not offer any protection against various nonbacterial pathogens such as viruses, protozoa, and prions and do not prevent the growth of microorganisms at low temperature.^[1,2] On the other hand, a single-dose injection vial is a vial of liquid medication intended for parenteral administration that is meant for use in a single patient for a single case/procedure/injection.^[3] These are preservative-free vials and are intended to be used only once.^[4,5]

MDVs are associated with reduced economic costs and environmental waste. However, these vials are prone to bacterial contamination and their use has been reported to be a potential source of infections in different studies.^[1] Various factors might affect the quality and sterility of medication present in these vials and are as follows: (a) number of withdrawals made from the vial; (b) sterility of the techniques employed by healthcare personnel; (c) injection of environmental air into the vial during extraction; (d) duration of use and storage; (e) storage conditions such as temperature and exposure to sun; and (f) presence of preservatives.^[6] Most of the reported outbreaks associated with MDVs have been related directly to poor aseptic techniques such as lack of hand hygiene, unacceptable practises of administering the same solution to more than one patient, and entering a vial with a used syringe and needle and leaving needle in the stopper.^[2]

This study was carried out with the aim of assessing knowledge and common practises of nursing staff working in a super-specialty hospital while dealing with parenteral medication. The contamination rate of content of in-use MDVs collected during the study was also recorded.

Subjects and Methods

A pilot study was conducted in a super-specialty hospital from June to December 2016. This study was divided into two phases, and the convenience sampling method was employed. In the first phase, information about knowledge and common practises

of 100 nursing staff with respect to the usage of single and MDVs, respectively, was obtained and assessed. The study group was constituted by only those nurses who were posted in CardioThoracic and Vascular Surgery (CTVS), Cardiology, Neurosurgery, Neurology, Gastro surgery, Gastroenterology, and general Intensive Care Units (ICUs), respectively, of the hospital during daytime (9:00 AM to 4:00 PM). Questionnaires were distributed among all members of the study group, and their responses were recorded.

In the second phase, 40 in-use MDVs containing some remnants were collected from the aforementioned ICUs without prior intimation. Relevant information such as the drug type, production date, expiration date, beyond-use date, date of opening the vials, labeling of vials, average number of times vials entered with sterile injection needles per day, manufacturer details, and storage conditions were recorded. The volume of 1 ml content of each of these vials was inoculated into a tube containing 15 ml thioglycolate broth and incubated at 37°C for 10 days. The broth was visually examined every day and subcultured onto blood, chocolate, and Sabouraud Dextrose agar plates on alternate days within 10 days or any time that the appearance seemed turbid.^[1] The microbial isolates thus obtained were identified using standard guidelines and recorded.^[7]

Results

The study group was constituted by 70 females and 30 males. The mean work experience \pm standard deviation of this group was 4.1 ± 1.9 years. Tables 1 and 2, respectively, depict the results of questionnaire-based assessment of the study group regarding knowledge about single and MDVs. These results show that the study group members had sufficient knowledge about various aspects of handling single and MDVs, respectively, such as hand hygiene, disinfection, checking of vial labels, and expiry date. However, some participants were unaware of the importance of recording the date of opening of MDVs and therefore were unsure about discarding these vials once the beyond-use date was reached. Out of the 40 in-use MDVs obtained for culture, 20 each contained insulin and heparin, respectively. The characteristics of these MDVs have been depicted in Table 3. The list of microorganisms isolated in culture from vials has been shown in Table 4. Medication present in 10 out of 40 in-use multidose injection vials was found to be contaminated, thereby, amounting to a contamination rate of 25%.

Low hand hygiene compliance rate of 55% was observed in all ICUs visited during the course of this study. None of the injection vials being used for multiple dosing were appropriately labeled as “Multidose Vials.” On an

Table 1: Questionnaire-based assessment of study group regarding knowledge about single-dose injection vials*

List of questions	ICU wise responses obtained													
	CTVS (n=15), n (%)		Cardiology (n=14), n (%)		Neurosurgery (n=15), n (%)		Neurology (n=14), n (%)		Gastro surgery (n=14), n (%)		Gastroenterology (n=13), n (%)		General ICU, n (%)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Whether used for a single patient for a single injection?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether discarded after every use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether a new needle and syringe is used for every injection?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether hands are washed properly before handling medication?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether diaphragm of the vial is disinfected with spirit before use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether medication is drawn in a clean medication preparation area?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether label is checked before each use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether expiration date is checked before use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether used if expiration date has been reached?	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)
Whether vial contents are grossly examined for contamination before use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether it is checked that the vial used for each injection is fresh or already accessed/used?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
If already accessed then whether it is thrown away and a fresh vial is used instead?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether aware that single-dose vials lack preservatives?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether aware that if reused in future, it can get contaminated with bacteria and therefore infect patients?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether preferred over multidose vials?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)

*None of the study group members responded to the questions as "Don't know." ICU: Intensive care unit

Table 2: Questionnaire- based assessment of study group regarding knowledge about multi-dose injection vials**

List of questions	ICU wise responses obtained													
	CTVS (n=15), n (%)		Cardiology (n=14), n (%)		Neurosurgery (n=15), n (%)		Neurology (n=14), n (%)		Gastro surgery (n=14), n (%)		Gastroenterology N=13, n (%)		General ICU, n (%)	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Whether used for a single patient for a single injection?	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)
Whether discarded after every use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether a new needle and syringe is used for every injection?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether hands are washed properly before handling medication?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether diaphragm of the vial is disinfected with spirit before use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether medication is drawn in a clean medication preparation area?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether label is checked before each use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether expiration date is checked before use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether used if expiration date has been reached?	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)
Whether beyond use date is checked if the vial was previously used?	9 (60)	6 (40)	14 (100)	0 (0)	9 (60)	6 (40)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	9 (60)	6 (40)
Whether used if beyond use date has been reached?	6 (40)	9 (60)	0 (0)	14 (100)	6 (40)	9 (60)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	6 (40)	9 (60)
Whether vial contents are grossly examined for contamination before use?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether aware that multi-dose vials contain preservatives that limit bacterial growth?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether aware that preservatives in multi-dose vials are not protective against HIV/Hepatitis B/Hepatitis C?	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)	0 (0)
Whether preferred over single- dose vials?	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	15 (100)	0 (0)	14 (100)	0 (0)	14 (100)	0 (0)	13 (100)	0 (0)	15 (100)

**None of the study group members responded to the questions as "Don't know.". ICU: Intensive Care Unit

Table 3: Characteristics of in-use multidose insulin and heparin injection vials

Characteristics of multidose injection vials	In-use multidose insulin injection vials*		In-use multidose heparin injection vials**	
	Yes, n/N1 (%)	No, n/N1 (%)	Yes, n/N2 (%)	No, n/N2 (%)
Appropriate labeling (single dose/multidose vials)	0/20 (0)	20/20 (100)	0/20 (0)	20/20 (100)
Manufacturing date	20/20 (100)	0/20 (0)	20/20 (100)	0/20 (0)
Expiration date	20/20 (100)	0/20 (0)	20/20 (100)	0/20 (0)
Beyond use date	0/20 (0)	20/20 (100)	0/20 (0)	20/20 (100)
Date and time of opening the vial	12/20 (60)	8/20 (40)	10/20 (50)	10/20 (50)
Average number of times vials entered with sterile injection needles per day				
1-5	15/20 (75)	-	12/20 (60)	-
6-10	5/20 (25)	-	8/20 (40)	-
>10	-	-	-	-
Duration of use (h)				
<24	12/20 (60)	-	14/20 (70)	-
24-48	4/20 (20)	-	5/20 (25)	-
>48	4/20 (20)	-	1/20 (5)	-
Manufacturer details				
Indian company	20/20 (100)	-	20/20 (100)	-
Foreign company	0/20 (0)	-	0/20 (0)	-
Storage conditions				
Refrigerator	20/20 (100)	-	20/20 (100)	-
Room temperature	0/20 (0)	-	0/20 (0)	-

*N1: Number of in-use multidose insulin injection vials=20; **N2: Number of in-use multidose heparin injection vials=20

Table 4: List of microorganisms isolated in culture from in-use multidose insulin and heparin injection vials

Organisms isolated	In-use multidose insulin injection vials* n/N1 (%)	In-use multidose heparin injection vials** n/N2 (%)
<i>Acinetobacter</i> spp.	1/20 (5)	-
Aerobic spore-bearing bacilli	1/20 (5)	1/20 (5)
<i>Aspergillus</i> spp.	-	1/20 (5)
Coagulase-negative <i>Staphylococcus</i> spp.	1/20 (5)	3/20 (15)
<i>Staphylococcus aureus</i>	2/20 (10)	0/20 (0)
Total	5/20 (25)	5/20 (25)

*N1: Number of in-use multidose insulin injection vials=20; **N2: Number of in-use multidose heparin injection vials=20

average, a single MDV was used for three to four patients in all ICUs. The beyond-use date was not mentioned on any of the MDVs. The contents of in-use MDVs were discarded as per the policy framed by in-charge nurses of different ICUs and varied from 48 hours up to 1 week from the date of opening. All study group members preferred to use single dose over MDVs owing to the risk of contamination and subsequent infection in the patients associated with the latter.

Certain interesting observations were noticed while visiting and interacting with nursing staff posted in CTVS, Neurosurgery, and general ICUs, respectively. First, 40% of nursing staff posted in these ICUs were not aware of the difference between expiration and beyond-use dates, respectively, of MDVs. Second, it was a common practise in these ICUs to keep a needle inserted through the rubber diaphragm of in-use MDVs. This needle was never replaced with a fresh needle every time while drawing the drug from these vials using a sterile syringe. Third, the rubber diaphragm

was never disinfected with spirit before withdrawing the medication from these injection vials. Further, it was also observed that some nursing staff in these ICUs used to seal the diaphragm of in-use MDVs with surgical tape before storing in the refrigerator. Fourth, the in-use MDVs were usually kept in the immediate patient treatment area and were not dedicated for single-patient use.

Discussion

In the present study, contamination rate of MDVs was 25%. Although the knowledge of most study group members was up to the mark as revealed by questionnaire-based assessment, many faulty practises were observed which could have contributed to high contamination rate and are as follows: low-hand hygiene compliance, lack of disinfection of rubber diaphragm of in-use vials, practise of keeping a needle inserted through the rubber diaphragm of these vials, keeping the vials in the immediate treatment area without being dedicated

for single-patient use, practise of sealing the diaphragm of in-use vials with surgical tape before storing in refrigerator, lack of mention of opening date and time on vial labels, and lack of understanding of simple concepts such as expiration and beyond-use dates, respectively.

Studies on MDVs have revealed considerable variation in bacterial contamination rates ranging from 0% to 27%.^[8] In a study conducted by Khalili *et al.*, none of the in-use MDVs which were kept for multiple uses in the wards were culture-positive. The low-microbial contamination of hands of nursing staff, air, and surfaces of treatment room was cited as a possible reason for the low contamination rate of contents obtained from these vials.^[6] A contamination rate of 5.36% with bacteria and fungi, in the content of single and MDVs, respectively, used in different wards of a teaching hospital situated in Iran was documented by Baniasadi *et al.*^[1] The sterility of multidose insulin vials was determined up to 50 days by Rathod *et al.* The authors showed bacterial contamination in 8 of 69 insulin vials and concluded that antibacterial preservatives were more effective at room temperature than at refrigerator temperature.^[9] Bacterial contamination was reported in 5.6% of in-use MDVs in a major referral teaching hospital in Shiraz, Southwest of Iran. The most commonly identified organism in this study was *Staphylococcus epidermidis*.^[10]

Administration of a contaminated infusates is one of the commonly identified causes of nosocomial bloodstream infections.^[1] Contamination of the infusate usually occurs extrinsically during manipulation of the fluid before the administration to the patient.^[11] MDVs used in the hospital settings are normally kept in the immediate patient treatment areas. Inadvertent contamination of these vials is more likely to happen through direct or indirect contact with potentially contaminated surfaces or equipments.^[1] Poor aseptic techniques employed during successive uses appear to be most likely route of contamination responsible for considerable morbidity and mortality.^[11] The most common organisms causing nosocomial infections as per SCOPE database are as follows: coagulase-negative *Staphylococcus* spp.(31%), *Staphylococcus aureus* (20%), *Enterococcus* spp.(9%), and *Candida* spp.(9%).^[8] All these microorganisms can grow rapidly at room temperature in a variety of solutions. In our study also, coagulase-negative *Staphylococcus* spp. was the most common bacterial isolate followed by *S. aureus*, aerobic spore-bearing bacilli, and *Acinetobacter* spp., respectively. An interesting finding of our study was the isolation of *Aspergillus* spp. from a multidose heparin injection vial. This could be an environmental contaminant owing to multiple pricks in these vials and their storage at different temperatures.

Outbreaks related to unsafe injection practises indicate that some healthcare personnel are either unaware of,

do not understand or do not adhere to basic principles of infection control and aseptic techniques. Research has shown that up to 25% of healthcare workers re-enter injection vials with needles just injected into the patients.^[12] Needles left in the rubber diaphragm of injection vials might encourage the use of same syringe to repeatedly draw medications for one patient, thereby increasing the possibility of contamination and infection among subsequent patients.^[11] Similar observation was obtained in our study as it was a common practise among nursing staff of some ICUs to keep a needle inserted through the rubber diaphragm of in-use MDVs which was never replaced with a fresh needle every time while drawing the drug from these vials. In a study conducted by Arrington *et al.*, it was shown that a slight alteration in the drug aspiration technique could cause a significant difference in the incidence of MDVs contamination.^[13]

According to the Centers for Disease Control and Prevention (CDC) guidelines, MDVs should be dedicated to a single patient whenever possible. If used for more than one patient, these should only be kept and accessed in a dedicated medication preparation area away from the immediate patient treatment areas. If a multidose vial enters an immediate patient treatment area, it should be dedicated for single-patient use only. Ideally, all medication preparation should occur in a dedicated medication preparation area (e.g., nurses station), away from immediate patient treatment areas. However, the following criteria must be fulfilled if there is a need to access multidose vials in the patient room: (a) the vial must be dedicated for single-patient use only; (b) the patient should be housed in a single-patient room; and (c) all medication preparation should be performed in a designated clean area that is not adjacent to potential contamination sources (e.g., sink, used equipment). Following medication preparation, the vials should be stored as per manufacturer's instructions. Medication vials should always be discarded whenever sterility is compromised or questionable^[14]

The United States Pharmacopeia General Chapter 797 recommends the following for multidose vials of sterile pharmaceuticals: If a multidose has been opened or accessed (e.g., needle-punctured), it should be dated and discarded within 28 days unless the manufacturer specifies a different (shorter or longer) date for that opened vial. If a multidose vial has not been opened or accessed (e.g., needle-punctured), it should be discarded as per manufacturer's expiration date. The manufacturer's expiration date refers to the date after which an unopened multidose vial should not be used. The beyond-use date refers to the date after which an opened multidose vial should not be used. The beyond-use date should never exceed the manufacturer's original expiration date.^[15]

Our study had several shortcomings such as small sample size, sampling methodology, and study design. Since the first part of this study dealt with the evaluation of knowledge and practises of nursing staff, the KAP (Knowledge, Attitude and Practises) methodology could have been employed. Studies (either single or multicentric) can be conducted in the future using large sample size with the view of correlating microbial contamination with number of times MDVs were entered. Appropriate regression models can be used to correlate contamination of MDVs with various risk factors. Outcomes such as bloodstream infections in hospitalized patients can also be correlated with microbial contamination of MDVs. In addition, bloodstream infection rates in the patients receiving medication from multidose and single dose injection vials, respectively, can also be compared.

Conclusions

The use of MDVs is a convenient and economical option in developing countries such as India. However, their use is also associated with the risk of contamination and nosocomial outbreaks of life-threatening bloodstream infections. Healthcare professionals must strictly adhere to basic infection control practises as per standard guidelines to minimize the incidence of hospital-acquired infections. Education regarding infection control measures as suggested by CDC must be imparted to all healthcare professionals on a regular basis. Effective implementation of these measures should be given top most priority in all healthcare settings.

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Conflicts of interest

There are no conflicts of interest.

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