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Incompatibility of IV admixture administration among hospitalized patient at Referral Hospital in Banyumas Regional

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ABSTRACT: Drug administration to inpatients in referral hospitals is generally performed using intravenous (IV) admixtures. IV admixtures can cause incompatibility problems that can affect the stability and bioavailability of the drugs. This study aimed to determine the potential for incompatibility problems in administering IV admixtures to inpatients in referral hospitals in the Banyumas region. This was a descriptive observational study. Data collection was carried out prospectively with the inclusion criteria of non-cytostatic IV admixtures administered to inpatients from March to May 2024. The potential for incompatibility in IV admixtures was determined based on visual observations and pH values carried out in the laboratory. In addition, we analyzed the Handbook of Injectable Drugs. The results of the study showed that 1,516 IV admixtures were obtained within 3 months. Of the 1,516 IV admixtures, 40 different IV admixtures had different characteristics. The characteristics of IV admixtures obtained at this referral hospital consisted of IV admixtures-small volume parenteral (36%), IV admixtures-large volume parenteral (5%), and reconstitution (59%). The solvents used included water for injection (94.65%), NaCl 0.9%, and RingerLactate (1.39%). Incompatibility occurred in a mixture of Sodium Phenytoin 50 mg/mL with NaCl 0.9% at concentrations as high as 0.264% (4 occurrences out of 1,516 IV mixtures), characterized by the formation of crystals after mixing. From this study, it can be concluded that the administration of IV admixtures to inpatients at the Banyumas Referral Hospital has a low potential for incompatibility (0.264%). However, the mixture of sodium phenytoin with 0.9% NaCl has been proven to cause crystal formation due to a decrease in pH, thus requiring special attention in the practice of mixing intravenous drugs.

KEYWORDS: IV admixtures; Banyumas; crystals; incompatibilities.

INTRODUCTION

Most hospitalized patients receive parenteral therapy, and in many cases, patients receive more than one intravenous preparation mixed in a single container before administration [1]. This mixing increases the risk of incompatibilities, particularly physical incompatibilities, characterized by visual changes such as precipitation, crystallization, turbidity, discoloration, and emulsion breakdown [1],[2]. Clinically, incompatibilities not only affect drug stability and bioavailability but can also lead to therapeutic failure and increase the risk of adverse events. The presence of particles or crystals in IV admixtures has been reported to trigger platelet aggregation and potentially cause serious complications in patients [1], [3], [4], [5], [6].

Several studies in Indonesia have indicated that IV admixture incompatibility remains a significant problem. A study at Surakarta Hospital reported a 19.5% incidence of incompatibility in parenteral admixtures [7], while a study in the ICU of PKU Muhammadiyah Hospital, Yogyakarta, found 50 incompatibility events in 79 patients [3]. These findings indicate a high risk of incompatibility, particularly in patients undergoing complex therapies. However, these studies are limited to parenteral preparations used in specific hospitals or patient groups and thus do not provide a comprehensive overview of the types of IV admixtures and the potential for incompatibilities at this referral hospital.

To date, data on the characteristics of IV admixtures and their potential incompatibilities at regional referral hospitals, particularly in Banyumas, remain limited. Meanwhile, referral hospitals generally handle

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patients with more complex therapies, potentially increasing the risk of incompatibilities and their impact on patient safety. Therefore, research is needed to provide a comprehensive overview of IV admixture types, along with data on the potential for incompatibilities in daily clinical practice at Banyumas Regional Referral Hospital. This study aimed to identify the characteristics of IV admixtures and evaluate the potential for incompatibilities among IV admixtures administered to inpatients at Banyumas Regional Referral Hospital. This is an effort to support improved patient safety and clinical pharmacy practices.

▪ MATERIALS AND METHODS

Materials

The materials used were samples of non-cytostatic IV admixtures, including ampicillin 1 g, ampicillin 2 g, ampicillin sulbactam 1.5 g, meropenem trihydrate 0.5 g, hyson 100 mg, cefotaxime 1 g, amikacin 500 mg, aminophylline 24 mg/mL, dexamethasone 5 mg/mL, phenobarbital 50 mg/mL, ranitidine 25 mg/mL, cefazolin 1 g, ceftriaxone 1 g, omeprazole 40 mg, ondansetron 4 mg/mL, cefepime 1 g, lansoprazole 30 mg, methylprednisolone 125 mg, pantoprazole, ceftazidime 1 g, ketorolac 30 mg/mL, solvinex 2 mg, MgSO4 40%, dobutamine 250 mg/5 mL, phenytoin sodium 100 mg/2 mL, and oxytocin 10 IU. The solvents used were water for injection, 0.9% NaCl, and Ringer's Lactate. The laboratory equipment used included a pH meter (OHAUS ST3100-F), a clarity tester (black-and-white background), syringes, infusion sets, and glass tubes. In addition to laboratory observations, this study used references from the Injectable Drugs Guide and Handbook of Injectable Drugs for compatibility analysis. Data collection used an instrument in the form of an observation sheet validated by experts (CVI = 1).

Methods

Study design and setting

This was a descriptive observational study with a prospective approach [8]. The study was conducted from March to May 2024 at Banyumas Regional Referral Hospital.

Population and sample

The study population consisted of all intravenous drug mixtures administered to inpatients during the study period (Perina, Kanthil, PICU, and Flamboyan rooms). The sampling method used was purposive sampling, namely IV Admixtures that met the inclusion criteria during the study period. The inclusion criteria were mixtures consisting of at least two intravenous preparations, including small volume parenteral (SVP), large volume parenteral (LVP), and reconstituted injectable preparations. The exclusion criterion was the use of cytostatic preparations. The total number of samples observed was 1,516 IV Admixtures.

Data collection procedure

Data were collected prospectively. Samples were prepared in the hospital inpatient ward and then taken to the laboratory for direct visual and pH measurements. Observations were conducted immediately to reflect real-world hospital conditions, where the prepared preparations were administered directly to patients without any storage. Data were recorded on an observation sheet, which included the type of drug mixed, the type of solvent used, the mixture category (SVP, LVP, or reconstitution), and the results of the laboratory observations.

Assessment of incompatibility

Intravenous admixture incompatibility was assessed by visual observation and pH measurements. Visual observations were performed against a black-and-white background to identify color changes, precipitate formation, turbidity, or the presence of particles [9], [10], [11]. pH measurements were performed before and after mixing using a calibrated pH meter [11], [12]. In addition, mixture compatibility was verified using the Injectable Drugs Guide and the Handbook of Injectable Drugs.

Data analysis

Data were analyzed descriptively by calculating the frequency and percentage of observed intravenous mixtures (drug name, strength, solvent type, and solvent volume), the type of intravenous mixture, and the

incidence of incompatibilities. The results of the analysis are presented in tables and figures to facilitate the interpretation of the data.

Ethical considerations

This study was approved by the Ethics Committee of the Banyumas Regional Referral Hospital (No.294/KEPK-RSUD/III/2024). Patient identities and data were kept strictly confidential throughout the study. This was an observational study that did not involve direct patient intervention.

▪ RESULTS

Overview of IV admixtures

During the study period from March to May 2024, 1,516 intravenous mixtures that met the inclusion criteria were identified in four wards of the Banyumas Regional Referral Hospital: Perina, Kanthil, PICU, and Flamboyan. These findings indicate that intravenous mixture preparation is routinely performed as part of inpatient therapeutic management of patients with cancer. This large number of preparations also reflects the high use of parenteral therapy in hospitalized patients.

The types of intravenous admixtures prepared in this hospital were classified as reconstituted, small volume parenteral (SVP), and large volume parenteral (LVP). Reconstitution was defined as the preparation of injectable powder formulations by adding an appropriate diluent prior to their administration. SVP refers to admixtures involving injectable drugs with diluents or other injectable agents in a total volume of less than 100 mL. LVP refers to admixtures involving injectable drugs mixed with infusion fluids in a total volume exceeding 100 mL.

Characteristic of IV admixtures

Based on observations conducted in four wards at the Banyumas Regional Referral Hospital during the study period, 2,941 parenteral preparations were prescribed to inpatients. A total of 1,516 parenteral preparations met the inclusion criteria for this study.

The parenteral preparations were mixed using solvents on average. The solvents used included Water for Injection (WFI), which accounted for 94.657%; Sodium Chloride 0.9%, which accounted for 3.957%; and Ringer's Lactate (RL), which accounted for 1.385%. Of the total 1,516 IV Admixtures, the types were classified as reconstituted (58.6%), IV SVP Admixtures (36.1%), and IV LVP Admixtures (5.3%), totaling 40 IV Admixtures, as shown in Table 1.

Table 1. Characteristics of intravenous admixtures in Inpatients at Referral Hospitals in Banyumas Regional.

Room	Drug name	Solvent	Vol (mL)	Type of IV admixtures	n	%
Perina	Ampicillin 1 g	WFI	10	Reconstitution	170	11.21
	Ampicillin sulbactam 1.5 g	WFI	10	Reconstitution	60	3.958
	Meropenem trihydrate 0.5 g	WFI	10	Reconstitution	50	3.298
	Hyson® 100 mg	WFI	4	Reconstitution	11	0.726
	Cefotaxime 1 g	WFI	4	Reconstitution	1	0.066
	Amikacin 500 mg	WFI	4	SVP	74	4.881
	Aminophylline 24 mg/mL	WFI	4	SVP	32	2.111
	Dexamethasone 5 mg/mL	WFI	4	SVP	18	1.187
	Phenobarbital 50 mg/mL	WFI	4	SVP	29	1.913
	Ranitidine 25 mg/mL	WFI	4	SVP	59	3.892
Kanthil	Ampicillin 1 g	WFI	5	Reconstitution	100	6.596
	Ampicillin sulbactam 1.5 g	WFI	5	Reconstitution	17	1.121
	Meropenem trihydrate 0.5 g	WFI	5	Reconstitution	8	0.528
	Cefazoline 1g	WFI	5	Reconstitution	3	0.198
	Cefotaxime 1 g	WFI	5	Reconstitution	18	1.187
	Ceftriaxone 1 g	WFI	5	Reconstitution	120	7.916
	Omeprazole 40 mg	WFI	4	Reconstitution	107	7.058
	Ondansetron 4 mg/2mL	WFI	4	SVP	200	13.19
PICU	Meropenem trihydrate 1g	WFI	10	Reconstitution	12	0.792

Room	Drug name	Solvent	Vol (mL)	Type of IV admixtures	n	%
Flamboyan	Cefepime 1 g	WFI	5	Reconstitution	4	0.264
	Cefepime 1 g	WFI	10	Reconstitution	6	0.396
	Lansoprazole 30 mg	WFI	10	Reconstitution	10	0.660
	Methylprednisolone 125 mg	WFI	2	Reconstitution	38	2.507
	Pantoprazole 40 mg	WFI	5	Reconstitution	11	0.726
	Cefazoline 1g	WFI	10	Reconstitution	10	0.660
	Cefotaxime 1g	WFI	10	Reconstitution	20	1.319
	Ceftazidime 1g	WFI	10	Reconstitution	8	0.528
	Ceftriaxone 1g	WFI	10	Reconstitution	104	6.860
	Ketorolac 30 mg/mL	WFI	2	SVP	98	6.464
	Solvinex® 2 mg	WFI	4	SVP	33	2.177
	$MgSO_4$ 40%	WFI	25	SVP	4	0.264
	Aminophylline 24 mg/mL	NaCl 0.9%	500	LVP	1	0.066
	Ampicillin 2 g	NaCl 0.9%	100	LVP	6	0.396
	Dobutamine 250 mg/5mL	NaCl 0.9%	50	LVP	1	0.066
	Phenytoin 100 mg/2mL	NaCl 0.9%	100	LVP	4	0.264
	Meropenem 2 g	NaCl 0.9%	100	LVP	4	0.264
	Cefazoline 2 g	NaCl 0.9%	100	LVP	21	1.385
	Ceftriaxone 2 g	NaCl 0.9%	100	LVP	23	1.517
	Oxytocin 10 IU	RL	500	LVP	16	1.055
	Oxytocin 10 IU dan Methylergometrine maleate 0.2 mg	RL	500	LVP	5	0.330

Information:
WFI= water for injection; RL= Ringer's lactate; SVP= small volume parenteral; LVP= large volume parenteral; n= number of IV admixtures

Incidence of incompatibility

To determine the occurrence of incompatibilities, visual observations (color and particles/precipitates) and pH measurements were performed on 40 IVAdmixtures. Thirty-nine IV Admixtures were compatible, and one was incompatible. Incompatibility was observed in the mixture of phenytoin and 0.9% NaCl. The observational data are presented in Table 2.

Table 2. Laboratory observation results and references.

IV admixtures	pH before mixing	Observation Results (after mixing)		*Reference [13], [14]	Compatibility conclusion
		Visual	pH		
Ampicillin 1 g + WFI (10 mL)	9.31± 0.11	clear, no particles	9.10±0.07	Compatible	Yes
Ampicillin sulbactam 1.5 g+WFI (10 mL)	9.28± 0.11	clear, no particles	8.87±0.15	Compatible	Yes
Meropenem trihydrate 0.5 g + WFI	8.3±0.04	clear, no particles	8.03±0.09	Compatible	Yes
Hyson® 100 mg + WFI	4.23±0.03	clear, no particles	4.43±0.19	Compatible	Yes
Cefotaxime 1 g + WFI (4 mL)	5.15±0.06	clear, no particles	5.48±0.15	Compatible	Yes
Amikacin 500 mg + WFI	4.47±0.08	clear, no particles	4.92±0.08	Compatible	Yes
Aminophylline 24 mg/mL + WFI	9.01±0.02	clear, no particles	8.67±0.07	Compatible	Yes
Dexamethasone 5 mg/mL + WFI	7.62±0.07	clear, no particles	7.51±0.07	Compatible	Yes
Phenobarbital 50 mg/mL + WFI	9.83±0.09	clear, no particles	9.06±0.24	Compatible	Yes
Ranitidine 25 mg/mL + WFI	6.98±0.04	clear, no particles	7.21±0.01	Compatible	Yes
Ampicillin 1 g + WFI (5 mL)	9.31±0.11	clear, no particles	9.18±0.07	Compatible	Yes
Ampicillin sulbactam 1.5 g + WFI (5 mL)	9.28±0.11	clear, no particles	8.82±0.04	Compatible	Yes
Meropenem trihydrate 0.5 g + WFI	8.3±0.04	clear, no particles	8.80±0.01	Compatible	Yes
Cefazoline 1g + WFI (5 mL)	4.95±0.06	clear, no particles	4.95±0.03	Compatible	Yes
Cefotaxime 1g + WFI (5 mL)	5.15±0.06	clear, no particles	5.15±0.07	Compatible	Yes
Ceftriaxone 1 g + WFI (5 mL)	6.46±0.07	clear, no particles	7.13±0.06	Compatible	Yes
Omeprazole 40 mg + WFI	10.61±0.09	clear, no particles	10.53±0.06	Compatible	Yes
Ondansetron 4 mg/2mL + WFI	3.84±0.09	clear, no particles	4.00±0.07	Compatible	Yes
Meropenem trihydrate 1g + WFI	8.3±0.04	clear, no particles	8.04±0.04	Compatible	Yes
Cefepime 1 g + WFI (5 mL)	5.56±0.02	clear, no particles	5.05±0.05	Compatible	Yes

IV admixtures	pH before mixing	Observation Results (after mixing)		*Reference [13], [14]	Compatibility conclusion
		Visual	pH		
Cefepime 1 g + WFI (10 mL)	5.56±0.02	clear, no particles	5.10±0.07	Compatible	Yes
Lansoprazole 30 mg + WFI	11.91±0.11	clear, no particles	11.84±0.22	Unknown	Yes
Methylprednisolone 125 mg + WFI	7.91±0.06	clear, no particles	7.60±0.05	Compatible	Yes
Pantoprazole 40 mg + WFI	10.02±0.07	clear, no particles	9.87±0.13	Compatible	Yes
Cefazoline 1g + WFI (10 mL)	4.95±0.06	clear, no particles	5.20±0.06	Compatible	Yes
Cefotaxime 1g + WFI (10 mL)	5.15±0.06	clear, no particles	5.36±0.01	Compatible	Yes
Ceftazidime 1g + WFI	6.17±0.01	clear, no particles	6.48±0.12	Compatible	Yes
Ceftriaxone 1g + WFI (10 mL)	6.46±0.07	clear, no particles	6.79±0.06	Compatible	Yes
Ketorolac 30 mg/mL + WFI	7.29±0.03	clear, no particles	7.41±0.04	Compatible	Yes
Solvinex® 2 mg + WFI	3.31±0.09	clear, no particles	3.43±0.03	Unknown	Yes
$MgSO_4$ 40% + WFI	7.59±0.14	clear, no particles	7.43±0.55	Compatible	Yes
Aminophylline 24 mg/mL + NaCl 0.9%	9.01±0.02	clear, no particles	8.60±0.06	Compatible	Yes
Ampicillin 2 g + NaCl 0.9%	9.31±0.11	clear, no particles	8.94±0.01	Compatible	Yes
Dobutamine 250 mg/5mL + NaCl 0.9%	5.46±0.04	clear, no particles	5.28±0.92	Compatible	Yes
Phenytoin 100 mg/2 mL + NaCl 0.9%	11.68±0.07	floating particles	9.54±0.08	Unknown	No
Meropenem 2 g + NaCl 0.9%	8.3±0.04	clear, no particles	8.21±0.11	Compatible	Yes
Cefazoline 2 g + NaCl 0.9%	4.95±0.06	clear, no particles	4.85±0.26	Compatible	Yes
Ceftriaxone 2 g + NaCl 0.9%	6.46±0.07	clear, no particles	7.21±0.25	Compatible	Yes
Oxytocin 10 IU + RL	5.01±0.07	clear, no particles	6.41±0.23	Compatible	Yes
Oxytocin 10 IU dan Methylergometrine maleate 0.2 mg + RL	5.01±0.07	clear, no particles	6.53±0.04	Unknown	Yes

*Gray et al (2011) Injectable Drugs Guide; Trisel et al (2013) Handbook on Injectable Drugs 17ed [13], [14]

Case analysis of ıncompatibility

The visual observations and pH evaluation of the phenytoin sodium 100 mg/2 mL admixture with NaCl 0.9% are presented in Table 3 and Figure 1. Repeated examinations consistently revealed floating, needle-shaped particles (microscopically), indicating physical incompatibility. In addition, the measured pH values were below the standard reference range, suggesting that pH reduction contributed to the crystal formation after mixing.

Table 3. Visual observation results and pH values (Phenytoin 100 mg/2mL and NaCl 0.9%).

Observation method	Replication 1	Replication 2	Standard values [15]
Visuals using a white background	there are floating particles	there are floating particles	Clear
Visuals using a black background	there are floating particles	there are floating particles	Clear
Visual using a microscope (40x magnification)	needle-shaped particles	needle-shaped particles	Clear
pH value using pH meter	9.48	9.60	10-12.5

(**a**) (**b**) (**c**)

Figure 1. (**a**) Visuals using a white background; (**b**) Visuals using a black background; **(c)** Visual using a microscope (40x magnification).

DISCUSSION

Overview and characteristic of IV admixtures

Medications administered to inpatients in the four wards (Kanthil, PICU, Flamboyan, and Perina) were generally parenteral. This is consistent with Salamah and Kurniawati (2019), who stated that most medication administration in inpatient wards is parenteral, aiming for rapid onset of action [3]. Another reason for parenteral administration is that some patients cannot tolerate oral medications [16]. Parenteral preparations administered to inpatients are often mixed to meet patient needs, such as reconstitution and mixing of SVP and LVP. Based on observations, mixing in the Perina ward was performed by pharmacy staff using Laminar Air Flow (LAF) in a clean room. Meanwhile, in the Kanthil, PICU, and Flamboyan wards, nurses performed it in the wards, not in the LAF.

Furthermore, most parenteral preparations are mixed using Water for Injection (WFI) as a solvent. This is consistent with Gupta's (2016) research, which found that WFI is the most widely used solvent for sterile preparations in hospitals because of its endotoxin-free nature and compatibility with sterile preparations [17]. Table 1 shows that 4 mg/2 mL ondansetron injection diluted with WFI was the most commonly used mixture in inpatient wards and was included in the SVP (13.19%). The addition of WFI to these preparations aimed to lower the ondansetron injection concentration, thereby reducing patient pain. These findings align with those of Trissel (2013), who stated that the dilution of injectable preparations is recommended to reduce venous irritation and improve tolerability [13].

Incidence of incompatibility

This study found one incompatibility incident in the injection mixture of Phenytoin Sodium with 0.9% NaCl (0.136%). The mixture formed white particles and drastically reduced the pH (from 11.68 to 9.54) compared to other IV admixtures (Table 2). The findings of this study are consistent with those of Maharani (2014), who reported an incompatibility incident involving Phenytoin Sodium and 0.9% NaCl at Margono Soekarjo Regional General Hospital [18]. Raoulji and Kapadia (2022) stated that precipitation of phenytoin sodium was reported to clog implanted central venous access devices and can cause tissue irritation and necrosis [6], [19], [20].

Case analysis of incompatibility

The injection mixture of Phenytoin Sodium and 0.9% NaCl, in addition to forming white particles and drastically lowering the pH, was also observed to appear crystalline upon microscopic observation. The results are presented in Table 3 and Figure 1.

The pH measurements of two replicates of the phenytoin sodium mixture in 0.9% NaCl solution were 9.48 and 9.60, with an average of 9.540±0.0848. According to the Indonesian Pharmacopeia, Edition VI, and ASHP Injectable Drug Information, phenytoin sodium has a pH of 10–12.5 [15], [21]. The mixture of phenytoin sodium and 0.9% NaCl experienced a drastic decrease in its pH. The addition of 0.9% NaCl lowers the pH of phenytoin sodium. Leopoldino (2018) showed that 0.9% NaCl can lower pH, increase chloride levels, and reduce base excess [22]. A change in pH of more than 1 is a characteristic of drug incompatibility [23], [24]. Phenytoin sodium becomes less soluble in aqueous solutions as the pH decreases. The decrease in pH is caused by phenytoin sodium in water, which gradually absorbs carbon dioxide, neutralizing the initially alkaline solution and causing phenytoin sodium to dissociate in water into sodium cations (Na+) and phenytoin anions (DPH −). Phenytoin anions (DPH-) then react to form a weak acid that does not dissociate phenytoin (DPH), which has low solubility in water (32 mg/L), resulting in crystallization [25]. This is in line with the research by Salamah and Kurniawati (2019), who found that preparations with a wide pH range can affect the pH of the solution, resulting in incompatibility [3]. According to other researchers, if two or more intravenous drugs with acidic and basic pH are administered together or through a single infusion line, precipitation usually occurs. Therefore, drugs/solvents with an acidic pH should not be mixed or administered separately from drugs with a basic pH [26].

Inappropriate intravenous administration of phenytoin sodium can cause purple glove syndrome (PGS). PGS is characterized by dark purple to bluish discoloration accompanied by pain and edema distal to the intravenous phenytoin sodium injection site. Therefore, to prevent PGS, phenytoin sodium should be administered intravenously via an IV drip, diluted in 0.9% NaCl, and diluted to a final concentration of at least

5 mg/mL. Subsequently, the infusion should be initiated immediately and administered over a relatively short period or using a 0.22 µm inline filter [21]. Pharmacists provide education to personnel who mix the drugs. If signs of incompatibility appear, stop, record, and do not administer to patients.

The concentration of phenytoin sodium mixed with NaCl at this referral hospital was 0.98 mg/mL (100 mg/102 mL). Therefore, the cause of this incompatibility incident can be identified as an error in the solvent volume and the mixing of phenytoin sodium, which has a basic pH, with 0.9% NaCl, which has a pH range of 5-7. If signs of incompatibility appear, stop, record, and do not give to patients. The lack of information regarding the compatibility of IV Admixtures by personnel is a concern. Human Resources (HR) who prepare IV Admixtures need regular training to improve their knowledge and ensure the quality of service [4], [27], [28]. The IFRS or related institutions can organize training to ensure the quality of parenteral preparation mixtures [29].

Limitation

One limitation of this study is that the IV admixtures were prepared and observed under actual hospital conditions, where the mixtures were administered to patients immediately after mixing, without a holding period. Consequently, no observations were made of the IV admixtures after several minutes or hours. Therefore, this study cannot provide information on delayed incompatibilities or physical changes that may occur during the extended storage. This may limit the applicability of the findings to healthcare professionals, particularly pharmacists and nurses, in situations where IV admixtures require storage or delayed administration for several hours.

▪ CONCLUSION

The characteristics of IV admixtures administered to inpatients at Banyumas Regional Referral Hospital differed depending on the type and volume of the solvent. Of the 40 IV admixtures, one was found to be incompatible, a mixture of sodium phenytoin and 0.9% NaCl, as indicated by the presence of floating particles, crystals, and a decrease in pH. The administration of this admixture carries the risk of embolism or venous irritation, potentially threatening patient safety. These findings underscore the importance of compatibility screening before mixing parenteral preparations. Active collaboration between pharmacists and nurses is crucial to ensure safe drug mixing practices and use reliable compatibility references in daily practice. Given the limitation that IV admixtures are not monitored during extended storage, further studies are needed to evaluate their stability over time and provide more comprehensive evidence for their safe clinical application.

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