Contents lists available at IOCS

Science Midwifery

journal homepage: www.midwifery.iocspublisher.org

Incompatibility in the administration of intravenous parenteral preparations in the intensive care unit (ICU) in one of the hospitals in Indonesia

Johnson L.Tobing[1], Hakim Bangun[2], Anayanti Arianto[3]

[1]Undergraduate Program, Faculty of Pharmacy, Universitas Sumatera Utara, Medan, Indonesia

[2,3]Department of Pharmaceutics and Pharmaceutical Tehcnology, Universitas Sumatera Utara, Medan, Indonesia

ARTICLE INFO

Article history:

Received Jan 21, 2025
Revised Apr 15, 2025
Accepted Apr 21, 2025

Keywords:

Electronic Prescribing
Incompatible
Intravenous
Survey

ABSTRACT

The prescribing and administration of intravenous injection drug therapy to patients in hospitals is increasing to achieve immediate pharmacological effects but can have a high risk of incompatibility. Therefore, it is necessary to check for intravenous injection incompatibility before administering it. Identify incompatible pairs of intravenous injectable drugs in intensive care (ICU) rooms of hospitals in Indonesia. Survey of the incompatibility of Electronic Prescribing (E-Prescribing) of intravenous injection drugs in the ICU room retrospectively using the Lexicomp application. From the results of retrospective identification of electronic prescriptions for the period from January 2022 to May 2023, data was obtained on the number of patients of 165 people, consisting of 91 people receiving compatible prescriptions and 74 patients receiving incompatible prescriptions. The number of intravenous injection drugs used was 60 types with the number of incompatible drug pairs 102 and the frequency of incompatible drugs 303. From the results of the evaluation of the incompatibility mechanism of intravenous drug injection pairs, it was found that 68 pairs of acid-base reactions, 18 pairs of mixed solvent dilution, 8 pairs of gas formation, 6 pairs of broken emulsions and 2 pairs of ionic reactions. Identification of patients' electronic prescriptions is still found to be incompatible with drug pairs, therefore it is necessary to take precautions.

Corresponding Author:

Hakim Bangun,
Department of Pharmaceutics and Pharmaceutical Tehcnology,
Universitas Sumatera Utara,
Jalan Dr. T. Mansur No.9, Padang Bulan, Kec. Medan Baru, Kota Medan, Sumatera Utara, 20222, Indonesia
Email: hakim@usu.ac.id

INTRODUCTION

Intravenous drug administration has a high risk of being dangerous if an error occurs in administration because it is almost impossible to withdraw/remove the drug that has been given from the blood plasma except by administering an antidote. This complex intravenous therapy has the potential for danger and is prone to error, so a strategy is needed to reduce the risk and complications (Vijayakumar et al., 2014).

Providing health services to patients safely is important in every health facility (Okuyama et al., 2014) and is considered by the World Health Organization. Medical costs incurred related to damage caused by medication errors are estimated to reach US$ 42 billion a year (WHO, 2017) and unsafe practices related to drug administration include infusion of incompatible intravenous drugs, the most common drug-related side effects during hospitalization and can result in permanent damage that can often be avoided (Fahimi et al., 2008).

Intravenous drug incompatibility pairs during infusion can be found to occur due to precipitation due to differences in pH (Alvarez-Nunez & Yalkowsky, 1999). When two or more intravenous drugs that have acidic and basic pH are given in the same line, sediment/precipitation usually forms in the infusion tube (Hanifah, 2015)(Hanifah, 2020)(Akbar, 2020). The physical reaction of drugs usually refers to one of the separation or precipitation phases due to shifts in the relationship between ionization, nonionization and solubility. In chemical incompatibility, drugs may undergo many chemical degradation pathways such as oxidation, reduction, hydrolysis (Abdelkader et al., 2020)(Setyani & Putri, 2020)(Ulfa, n.d.).

The main risks associated with drug incompatibility are partial or complete catheter blockage which in turn leads to infusion delay, drug loss, formation of toxic components (Bernaerts et al., 2000), particle deposition in major organs such as kidneys, liver, and lungs and mechanical damage caused by particles in blood vessels and systemic inflammatory response syndrome (Kanji et al., 2010).

Based on previous research on intravenous injection drug incompatibility, Tissot et al (1999) has tested drug administration errors in the ICU where 18.6% were physicochemically incompatible, 63.2% errors on potential clinical effects and 26.3% were potentially life-threatening. Elisa D'Hurt (2019) conducted a study on anti-infective injections of 37 drug pairs in the ICU where 70.3% were found to be compatible, 8.1% were visually incompatible and 21.6% were incompatible after subvisual testing (D'Huart et al., 2019). Taxis (2004) reported that drug incompatibility is a common error in hospitals with a frequency of 25% and 2% have severe clinical impacts (Taxis & Barber, 2004). Balisa Mosisa et al (2020) conducted a study at Nekemte Referral Hospital and found 25.43% compatible, 28.94% incompatible, 7.01% variable and 38.59% undocumented (Mosisa et al., 2020). Laksmi Maharani et al (2014) conducted a study in the neurosurgery ward of Prof. Dr. Margono Soekarjo Hospital found a potential incompatibility rate of 0.45%, unknown compatibility 4.35% and compatible 95.20% (Maharani et al., 2014). Reza Rahmawati et al (2018) conducted a study on pediatric patients at Dr. Sardjito Hospital found that 73.7% of compatible drug pairs and 26.3% were unknown compatibility (Rahmawati et al., 2018). Siti Syahbarni et al (2021) conducted a study in the ICU room of a hospital in Semarang and found a picture of the compatibility of IV parenteral preparations of 3.72% incompatible, 25.71% compatible, 1.53% not clear, 0.41% no recommendation and 68.64% no information (Syahbarni et al., 2021). Maria Caeceillia Nanny Stiawati et al (2023) conducted a study in the ICU room of a hospital in Semarang and found 7.37% incompatible, 43.11% compatible, 47.81% no information, 0.81% not clear, and 0.89% no recommendation (Setiawati & Munisih, 2023).

Based on the results of the study above, it is necessary to conduct a retrospective survey of the incompatibility of electronic prescriptions for intravenous injection drugs in the ICU room of Dr. Pirngadi Hospital, Medan City.

RESEARCH METHOD

Survey of data collection on electronic prescribing of injectable drugs using the Hospital Information System (SIRS) application in ICU rooms during the period January 2022 to May 2023. Identify the incompatibility of injectable drug pairs using the Lexicomp application and survey information on how to administer injectable drugs to patients through medical personnel, nurses and literature. a) Equipment, Hospital Information System Application (SIRS), Lexicomp Application, Handbook Injectable drug; b) Material, Intravenous injection medication given in the

ICU room. The collection of electronic prescribing data for the period January 2022 to May 2023 was carried out in the SIRS room after receiving a letter of introduction for research and an information survey on how to administer intravenous injection drugs to patients through medical personnel, nurses and literature. Recapitulate the number and type of intravenous drugs used in the ICU room and how they are administered. Conducting intravenous injection drug incompatibility testing using the Lexicomp application to find out the number of intravenous drug incompatibility pairs and the frequency of incompatibility and how to prevent it.

RESULTS AND DISCUSSIONS

Data Analysis

Survey on the Identification of Intravenous Injection Drugs used in the ICU

Intravenous injection drugs used in the ICU of Dr. Pirngadi Hospital, Medan City, are 60 types, which can be seen in Table 1 below.

Table 1. List of intravenous injection drugs used in the ICU

No	Intravenous Injection Drug Names	Production
1	Albumin	PT. Difa Pharmalab - Jakarta
2	Amikacin SO4	PT. Dexa Medica - Palembang
3	Aminofilin	PT. Phapros - Semarang
4	Amiodarone HCl	PT. Darya Varia - Bogor
5	Ampicillin Sodium	PT. Meiji - Pasuruan
6	Atacrium Besylate	PT. Ethica Industri Farmasi- Bekasi
7	Atropine Sulfate	PT. Ethica Industri Farmasi- Bekasi
8	Azithromicin	PT. Bernofarm - Sidoarjo
9	Bupivacaine HC	PT. Novel Pharma - Bogor
10	Calcium Gluconate	PT. Dexa Medica - Palembang
11	Cefepime HCL	PT. Dexa Medica - Palembang
12	Cefotaxim	PT. Dexa Medica - Palembang
13	Ceftazidine	PT. Dexa Medica - Palembang
14	Ceftriaxone	PT. Dexa Medica - Palembang
15	Ciprofloxacin	PT. Dexa Medica - Palembang
16	Dexamethasone Sodium Phosphate	PT. Phapros - Semarang
17	Dextrose 5%	PT. Otsuka - Malang
18	Diazepam	PT. Mepropharm - Bandung
19	Diphenhidramin HCL	PT. Phapros - Semarang
20	Dobutamine HCL	PT. Dexa Medica - Palembang
21	Dopamin	PT. Dexa Medica - Palembang
22	Ephedrine SO4	PT. Ethica Industri Farmasi- Bekasi
23	Epinephrine HCl	PT. Phapros - Semarang
24	Fentanyl Sitrat	PT. Betamahakam - Jakarta
25	Furosemide	PT. Dexa Medica - Palembang
26	Gentamicin SO4	PT. Indofarma - Bekasi
27	Heparin Natrium	PT. Pratapa Nirmala - Tangerang
28	Insulin Glusuline	PT. Aventis Farma - Jakarta
29	Ketamine HCl	PT. Dexa Medica - Palembang
30	Ketorolac Tremethamine	PT. Hexapharma - Bekasi
31	Lansoprazole	PT. Pratapa Nirmala - Tangerang
32	Levofloxacin	PT. Mersifarma - Sukabumi
33	Lidocain HCl	PT. Phapros - Semarang
34	Magnesium SO4	PT. Otsuka - Malang
35	Meperidine HCL/Phetidine	PT. Kimia Farma - Jakarta
36	Meropenem	PT. Mepropharm - Bandung
37	Methylprednisolone Sodium Succinate	PT. Bernofarm - Sidoarjo
38	Metochlorpramide HCl	PT. Kimia Farma - Jakarta
39	Metronidazole	PT. Bernofarm - Sidoarjo
40	Midazolam	PT. Novel Pharma - Bogor
41	Morphin SO4	PT. Kimia Farma - Jakarta
42	Moxifloxacin HCl	PT. Bernofarm - Sidoarjo
43	Natrium Chlorida 0.9%	PT. Otsuka - Malang

No	Intravenous Injection Drug Names	Production
44	Nicardipine HCl	PT. Dexa Medica - Palembang
45	Norepinephrine bitartrate	PT. Hexapharma - Bekasi
46	Omeprazole Natrium	PT. Phapros - Semarang
47	Ondansetrone HCl	PT. Bernofarm - Sidoarjo
48	Phenobarbital Sodium	PT. Phapros - Semarang
49	Phenytoin Sodium	PT. Dexa Medica - Palembang
50	Potasium Chlorida/KCl	PT. Otsuka - Malang
51	Propofol	PT. PT Dankos - Jakarta
52	Pyridoxine	PT. Banyuwangi Pharma Utama-Banyuwangi
53	Ranitidine HCl	PT. Mepropharm - Bandung
54	Ringer injeksi	PT. Otsuka - Malang
55	Rocuronium Bromida	PT. Kalbe Farma - Jakarta
56	Sodium Bicarbonate	PT. Otsuka - Malang
57	Streptomisin SO4	PT. Phapros - Semarang
58	TNA 3 in 1 total nutrien	PT. Fresensius KABI - Bandung
59	Tramadol HCl	PT. Novel Pharma - Bogor
60	Tranexamic aid	PT. PT Dankos - Jakarta

Results of Identification of Incompatibility of Intravenous Injection Drug Pairs and Frequency of Incompatibility

From the results of the identification of the number of incompatibilities of intravenous injection pairs and the frequency of incompatibilities using the Lexicomp® application, it was found that there were 102 incompatible drug pairs with 303 incompatibilities. The mechanism of incompatibility of intravenous injection drug pairs can be seen in Table 2.

Table 2. Mechanism of incompatibility of the number of intravenous injection drug pairs

No	Mechanism of incompatibility of intravenous injection drug pairs	Total
1	Acid base reaction/pH difference	50
2	Acid pH difference reaction	13
3	Reaction of base pH difference	7
4	Ion reaction	3
5	Gas/bubble formation reaction	8
6	Emulsion damaged/broken	7
7	Mixed solvent	14

1. Incompatibility of intravenous injection partners based on acid-base reaction mechanisms/pH differences. The results of the identification of incompatibility of intravenous injection drug pairs obtained 70 pairs with a frequency of 233 times where the acid-base reaction/pH change from the administration of two intravenous injection drugs simultaneously will affect the initial pH of one of the injection drugs. Changes in pH will cause incompatibility of drug pairs in the form of the formation of sediment from one of the unstable drugs (YULIANI, 2021)(MOUDYTA, 2021)(Nurseta et al., 2022). In an acid-base reaction, H+ is submitted/released donating H+ to its base. This reaction can change the pH and solubility of the mixture. Because there are drug molecules that ionize (Anderson et al., 2014).

Table 3. Incompatibility based on acid-base reaction/pH differences of intravenous injection drugs available in hospital ICUs

	Acid-base intravenous injection drug pairs							Information
No	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
1	Acetaminophen	5 – 5,5	Infusion	Phenobarbital	9,2-10,2	Bolus	1	Acid-base reactions
2	Acetaminophen	5 – 5,5	Infusion	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
3	Amiodarone HCL	4,08	Infusion*	Meropenem	7,3-8,3	Bolus	1	Acid-base reactions

No	Acid-base intravenous injection drug pairs							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
4	Amiodarone HCL	4,08	Infusion*	Ranitidine HCl	6,7-7,3	Bolus	1	Acid-base reactions
5	Atropine Sulfate	3-3,6	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
6	Ceftazidine	5-8	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
7	Ceftriaxone	6,6	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
8	Ciprofloxacin	3,3-3,9	Infusion*	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	1	Acid-base reactions
9	Ciprofloxacin	3,3-3,9	Infusion*	Methylprednisolone Sodium Succinate	7-8	Bolus	1	Acid-base reactions
10	Dobutamin HCl	2,5-5,5	Infusion*	Ketorolac Tremethamine	6,9-7,9	Bolus	1	Acid-base reactions
11	Dobutamin HCl	2,5-5,5	Infusion*	Lansoprazole	11	Bolus	1	Acid-base reactions
12	Dobutamine HCL	2,5-5,5	Infusion*	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	6	Acid-base reactions
13	Epinephrine HCl	2,2-5	Infusion*	Phenobarbital Sodium	9,2-10,2	Bolus	1	Acid-base reactions
14	Epinephrine HCl	2,2-5	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
15	Fentanyl Sitrat	4-7,5	Infusion*	Phenytoin Sodium	12	Bolus	3	Acid-base reactions
16	Ketamine HCL	3,5-5,5	Bolus	Furosemide	8-9,3	Infusion*	3	Acid-base reactions
17	Ketamine HCL	3,5-5,5	Bolus	Insulin Regular	7-7,8	Infusion*	2	Acid-base reactions
18	Ketamine HCL	3,5-5,5	Bolus	Meropenem	7,3-8,3	Bolus	4	Acid-base reactions
19	Ketamine HCL	3,5-5,5	Bolus	Ringer Lactat	6-7,5	Infus	5	Acid-base reactions
20	Levofloxacin	3,8-5,8	Infus	Furosemide	8-9,3	Infus	11	Acid-base reactions
21	Levofloxacin	3.8-5.8	Infus	Lansoprazole	11	Bolus	2	Acid-base reactions
22	Levofloxacin	3.8-5.8	Infus	Phenytoin Sodium	12	Bolus	2	Acid-base reactions
23	Magnesium SO4	5,5-7	Bolus	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	3	Acid-base reactions
24	Meropenem	7,3-8,3	Bolus	Midazolam HCL	2,5-4	Infusion*	17	Acid-base reactions
25	Meropenem	7,3-8,3	Bolus	Nicardipine HCl	3,2-4,2	Infusion*	2	Acid-base reactions
26	Methylprednisolone Sodium Succinate	7-8	Bolus	Rocuronium Bromida	4	Bolus	1	Acid-base reactions
27	Metronidazole	4,5-7	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
28	Midazolam HCL	2,5-4	Infusion*	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	23	Acid-base reactions
29	Midazolam HCL	2,5-4	Infusion*	Lansoprazole	11	Bolus	2	Acid-base reactions
30	Midazolam HCL	2,5-4	Infusion*	Phenobarbital Sodium	9,2-10,2	Bolus	1	Acid-base reactions
31	Midazolam HCL	2,5-4	Infusion*	Phenytoin Sodium	12	Bolus	3	Acid-base reactions
32	Midazolam HCL	2,5-4	Infusion*	Omeprazole Na	9-10,5	Bolus	22	Acid-base reactions
33	Moxifloxacin HCL	5-6	Infusion*	Furosemide	8-9,3	Infusion*	1	Acid-base reactions
34	Nicardipine HCl	3,2-4,2	Infusion*	Dexamethasone Sodium	7-8,5	Bolus	6	Acid-base

No	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	Information
				Acid-base intravenous injection drug pairs				
				Phorpahte				reactions
35	Nicardipine HCl	3,2-4,2	Infusion*	Furosemide	8-9,3	Infusion*	5	Acid-base reactions
36	Nicardipine HCl	3,2-4,2	Infusion*	Lansoprazole	11	Bolus	1	Acid-base reactions
37	Nicardipine HCl	3,2-4,2	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
38	Norepinephrine bitartrate	3-4,5	Infusion*	Phenytoin Sodium	12	Bolus	2	Acid-base reactions
39	Ondansetrone HCL	3-4	Bolus	Furosemide	8-9,3	Infus*	5	Acid-base reactions
40	Ondansetrone HCL	3-4	Bolus	Lansoprazole	11	Bolus	1	Acid-base reactions
41	Ondansetrone HCL	3-4	Bolus	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
42	Phytomenadion	3,5-7	Bolus	Phenytoin Sodium	12	Bolus	2	Acid-base reactions
43	Potasium Chlorida/ KCL	4-8	Bolus	Lansoprazole	11	Bolus	1	Acid-base reactions
44	Pyridoxine HCl	2-3,8	Bolus	Furosemide	8-9,3	Infusion*	1	Acid-base reactions
45	Pyridoxine HCl	2-3,8	Bolus	Methylprednisolone Sodium Succinate	7-8	Bolus	1	Acid-base reactions
46	Ranitidine HCl	6,7-7,3	Bolus	Lansoprazole	11	Bolus	1	Acid-base reactions
47	Ranitidine HCl	6,7-7,3	Bolus	Phenytoin Sodium	12	Bolus	3	Acid-base reactions
48	Ringer Lactat	6-7,5	Bolus	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
49	Rocuronium Bromida	4	Bolus	Furosemide	8-9,3	Infus*	3	Acid-base reactions
50	Rocuronium Bromida	4	Bolus	Insulin Regular	7-7,8	Infusion*	2	Acid-base reactions
51	Azithromicin	6,4-6,6	Bolus	Midazolam HCL	2,5-4	Infusion*	1	pH Difference
52	Acetaminophen	5 – 5,5	Infusion	Metronidazole	4,5-7	Infusion	2	pH Difference
53	Amiodarone HCL	4.08	Infusion*	Levofloxacin	3,8-5,8	Infusion	2	pH Difference
54	Ceftazidine	5-8	Bolus	Midazolam HCL	2,5-4	Infusion*	1	pH Difference
55	Ceftriaxone	6,6	Bolus	Dobutamine HCL	2,5-5,5	Infusion*	6	pH Difference
56	Ceftriaxone	6,6	Bolus	Magnesium SO4	5,5-7	Bolus	5	pH Difference
56	Dexamethasone Na	7-8,5	Bolus	Phenytoin Sodium	12	Bolus	2	pH Difference
57	Furosemide	8-9,3	Infusion*	Lansoprazole	11	Bolus	2	pH Difference
59	Furosemide	8-9,3	Infusion*	Phenytoin Sodium	12	Bolus	1	pH Difference
60	Insulin Regular	7-7,8	Infusion*	Phenytoin Sodium	12	Bolus	1	pH Difference
61	Ketamine HCL	3,5-5,5	Bolus	Rocuronium Bromida	4	Bolus	6	pH Difference
62	Ketorolac Tremethamine	6,9-7,9	Bolus	Levofloxacin	3,8-5,8	Infusion	3	pH Difference
63	Ketorolac Tremethamine	6,9-7,9	Bolus	Midazolam HCL	2,5-4	Infusion*	11	pH Difference
64	Ketorolac Tremethamine	6,9-7,9	Bolus	Nicardipine HCl	3,2-4,2	Infusion*	3	pH Difference
65	Ketorolac Tremethamine	6,9-7,9	Bolus	Rocuronium Bromida	4	Bolus	8	pH Difference
66	Epinephrine HCl	2,2-5	Infusion*	Voluven	4-5,5	Infusion	1	pH Difference
67	Midazolam HCL	2,5-4	Infusion*	Albumin	4-7,4	Bolus	8	pH Difference
68	Lansoprazole	11	Bolus	Phenytoin Sodium	12	Bolus	1	pH Difference
69	Meropenem	7,3-8,3	Bolus	Phenytoin Sodium	12	Bolus	4	pH Difference
70	Methylprednisolone Sodium	7-8	Bolus	Phenytoin Sodium	12	Bolus	1	pH Difference

No	Acid-base intravenous injection drug pairs							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
	Succinate							
				Frequency of incompatibility			233	
				Number of IV couple incompatibilities			70	

a. Incompatibility of intravenous injection partners based on the administration of acidic drug infusion with bolus administration of basic drug. The results of the identification of incompatibility of intravenous injection drug pairs based on the administration of acidic drug infusions and basic drug boluses obtained 27 pairs with a frequency of 105 times.

Table 4. Incompatibility of drug pairs based on acidic drug infusion and basic drug bolus

No	Administration of intravenous injection drug pairs of acid through infusion/syringe pump and base as a bolus							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
1	Acetaminophen	5 – 5,5	Infusion	Phenobarbital	9,2-10,2	Bolus	1	Acid-base reactions
2	Acetaminophen	5 – 5,5	Infusion	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
3	Amiodarone HCL	4,08	Infusion*	Meropenem	7,3-8,3	Bolus	1	Acid-base reactions
4	Amiodarone HCL	4,08	Infusion*	Ranitidine HCl	6.7-7,3	Bolus	1	Acid-base reactions
5	Ciprofloxacin	3,3-3,9	Infusion	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	1	Acid-base reactions
6	Ciprofloxacin	3,3-3,9	Infusion	Methylprednisolone Sodium Succinate	7-8	Bolus	1	Acid-base reactions
7	Dobutamin HCl	2,5-5,5	Infusion*	Ketorolac Tremethamine	6,9-7,9	Bolus	1	Acid-base reactions
8	Dobutamin HCl	2,5-5,5	Infusion*	Lansoprazole	11	Bolus	1	Acid-base reactions
9	Dobutamine HCL	2,5-5,5	Infusion*	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	6	Acid-base reactions
10	Epinephrine HCl	2,2-5	Infusion*	Phenobarbital Sodium	9,2-10,2	Bolus	1	Acid-base reactions
11	Epinephrine HCl	2,2-5	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
12	Fentanyl Sitrat	4-7,5	Infusion*	Phenytoin Sodium	12	Bolus	3	Acid-base reactions
13	Levofloxacin	3,8-5,8	Infusion	Lansoprazole	11	Bolus	2	Acid-base reactions
14	Levofloxacin	3,8-5,8	Infusion	Phenytoin Sodium	12	Bolus	2	Acid-base reactions
15	Metronidazole	4,5-7	Infusion	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
16	Midazolam HCL	2,5-4	Infusion*	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	23	Acid-base reactions
17	Midazolam HCL	2,5-4	Infusion*	Lansoprazole	11	Bolus	2	Acid-base reactions
18	Midazolam HCL	2,5-4	Infusion*	Phenobarbital Sodium	9,2-10,2	Bolus	1	Acid-base reactions
19	Midazolam HCL	2,5-4	Infusion*	Phenytoin Sodium	12	Bolus	3	Acid-base reactions
20	Midazolam HCL	2,5-4	Infusion*	Omeprazole Na	9-10,5	Bolus	22	Acid-base reactions
21	Midazolam HCL	2,5-4	Infusion*	Meropenem	7,3-8,3	Bolus	17	Acid-base reactions
22	Nicardipine HCl	3,2-4,2	Infusion*	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	6	Acid-base reactions
23	Nicardipine HCl	3,2-4,2	Infusion*	Lansoprazole	11	Bolus	1	Acid-base reactions
24	Nicardipine HCl	3,2-4,2	Infusion*	Phenytoin Sodium	12	Bolus	1	Acid-base

No	Administration of intravenous injection drug pairs of acid through infusion/syringe pump and base as a bolus							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
								reactions
25	Nicardipine HCl	3,2-4,2	Infusion*	Meropenem	7,3-8,3	Bolus	2	Acid-base reactions
26	Norepinephrine bitartrate	3-4,5	Infusion*	Phenytoin Sodium	12	Bolus	2	Acid-base reactions
27	Ringer Lactat	6-7,5	Infusion	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
Frequency of incompatibility							105	
Number of IV couple incompatibilities							27	

Infusion* = Administration via Syringe pump

To prevent incompatibility of the above drug pair administration, the drug is administered with an on-off and flushing system in the following order; turn off the three-way acid drug infusion tap, flush with 0.9% NaCl fluid, inject a base bolus drug, flush with 0.9% NaCl fluid again and turn on the three-way acid drug infusion tap. This on-off system can prevent the occurrence of infusion-bolus incompatibility in the three way and extension tube (Hanifah, 2015).

b. Incompatibility of intravenous injection partners based on bolus administration of acidic drugs with infusion administration of basic drugs. The results of the identification of incompatibility of intravenous injection drug pairs based on the administration of acidic drug infusions and basic drug boluses obtained 7 pairs with a frequency of 21 times.

Table 5. Incompatibility of drug pairs based on acidic drug boluses and basic drug infusions

No	Administration of intravenous injection drug pairs of acid and base via bolus infusion/syringe pump							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
1	Ketamine HCL	3,5-5,5	Bolus	Furosemide	8-9,3	Infusion*	3	Acid-base reactions
2	Ketamine HCL	3.5-5.5	Bolus	Insulin Regular	7-7,8	Infusion*	2	Acid-base reactions
3	Ketamine HCL	3.5-5.5	Bolus	Ringer Lactat	6-7,5	Infusion*	5	Acid-base reactions
4	Ondansetrone HCL	3-4	Bolus	Furosemide	8-9,3	Infusion*	5	Acid-base reactions
5	Pyridoxine HCl	2-3,8	Bolus	Furosemide	8-9,3	Infusion*	1	Acid-base reactions
6	Rocuronium Bromida	4	Bolus	Furosemide	8-9,3	Infusion*	3	Acid-base reactions
7	Rocuronium Bromida	4	Bolus	Insulin Regular	7-7,8	Infusion*	2	Acid-base reactions
Frequency of incompatibility							21	
Number of IV couple incompatibilities							7	

Infusion* = Administration via Syringe pump

To prevent incompatibility of the above drug pair administration, the drug is administered with an on-off and flushing system in the following order; turning off the three-way infusion tap for basic drugs, flushing with 5% Glucose fluid, injecting an acid bolus drug, flushing with 5% Glucose fluid again and turning on the three-way infusion tap for basic drugs. This on-off system can prevent the occurrence of bolus-infusion incompatibility in the three way and extension tube.

c. Incompatibility of intravenous injection partners based on the administration of acidic drug infusion with the administration of basic drug infusion. The results of the identification of incompatibility of intravenous injection drug pairs based on the administration of acidic drug infusions and basic drug boluses obtained 3 pairs with a frequency of 17 times.

Tabel 6. Drug pair incompatibility based on acidic drug infusion and alkaline drug infusion

No	Administration of intravenous acid-base injection drug pairs by infusion							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
1	Levofloxacin	3,8-5,8	Infusion	Furosemide	8-9,3	Infusion*	11	Acid-base reactions
2	Moxifloxacin HCL	5-6	Infusion	Furosemide	8-9,3	Infusion*	1	Acid-base reactions
3	Nicardipine HCl	3,2-4,2	Infusion*	Furosemide	8-9,3	Infusion*	5	Acid-base reactions

Frequency of incompatibility	17
Number of IV couple incompatibilities	3

Infusion* = Administration via Syringe pump

To prevent incompatibility in administering the above drug pairs, infusion drugs are administered in the following manner: a) In the same vein using a multilumen central venous catheter (CVC) with the administration of acidic drug infusion and basic drug infusion in separate lumens so as to prevent contact between the two pairs of acidic and basic infusion drugs; b) In two different veins using peripheral intravenous catheters (PIVCs), where one vein is used to administer acidic infusion drugs and the other vein is used to administer alkaline infusion drugs.

d. Incompatibility of intravenous injection partners based on bolus administration of acidic drugs with bolus administration of basic drugs. The results of the identification of incompatibility of intravenous injection drug pairs based on the administration of acidic drug boluses and basic drug boluses obtained 13 pairs with a frequency of 21 times.

Table 7. Incompatibility of drug pairs based on acidic drug boluses and basic drug boluses

No	Bolus administration of intravenous acid-base injection drug pairs							Information
	Acid Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
1	Atropine Sulfate	3-3,65	Bolus	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
2	Ceftazidine	5-8	Bolus	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
3	Ceftriaxone	6,6	Bolus	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
4	Ketamine HCL	3,5-5,5	Bolus	Meropenem	7,3-8,3	Bolus	4	Acid-base reactions
5	Magnesium SO4	5,5-7	Bolus	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	3	Acid-base reactions
6	Rocuronium Bromida	4	Bolus	Methylprednisolone Sodium Succinate	7-8	Bolus	1	Acid-base reactions
7	Ondansetrone HCL	3-4	Bolus	Lansoprazole	11	Bolus	1	Acid-base reactions
8	Ondansetrone HCL	3-4	Bolus	Phenytoin Sodium	12	Bolus	1	Acid-base reactions
9	Phytomenadion	3,5-7	Bolus	Phenytoin Sodium	12	Bolus	2	Acid-base reactions
10	Potasium Chlorida/ KCL	4-8	Bolus	Lansoprazole	11	Bolus	1	Acid-base reactions
11	Pyridoxine HCl	2-3,8	Bolus	Methylprednisolone Sodium Succinate	7-8	Bolus	1	Acid-base reactions
12	Ranitidine HCl	6,7-7,3	Bolus	Lansoprazole	11	Bolus	1	Acid-base reactions
13	Ranitidine HCl	6,7-7,3	Bolus	Phenytoin Sodium	12	Bolus	3	Acid-base reactions
				Frequency of incompatibility			21	
				Number of IV couple incompatibilities			13	

Infusion* = Administration via Syringe pump

To prevent incompatibility in administering the above pairs of acidic drug boluses and basic drug boluses, this is done in the following mannerTo prevent incompatibility in administering the above pairs of acidic drug boluses and basic drug boluses, this is done in the following manner: 1) Flushing for administering a bolus to the same vein, if the first bolus of acidic medication is given, then flush with 5% glucose solution, inject the acidic bolus medication, flush with 5% glucose solution, then follow with a basic bolus of medication by flushing with 0.9% NaCl solution, inject the basic bolus medication, flush with 0.9% NaCl solution again; 2) In two different veins using peripheral intravenous catheters (PIVCs), where one vein is used to administer a bolus of acidic drugs and the other vein is used to administer basic drugs.

e. Incompatibility of intravenous injection partners of acidic drugs based on differences in acid pH. The results of the identification of incompatibility of intravenous injection drug pairs based on differences in acid pH obtained 13 pairs with a frequency of 57 times.

Table 8. Incompatibility of drug pairs based on differences in acid pH

No	Administration of intravenous injection acid drug pairs based on acid pH difference							Information
	Acid Medicine	pH	Giving	Acid Medicine	pH	Giving	Amount	
1	Azithromicin	6,4-6,6	Bolus	Midazolam HCL	2,5-4	Infusion*	1	Acid pH Difference
2	Ceftazidine	5-8	Bolus	Midazolam HCL	2,5-4	Infusion*	1	Acid pH Difference
3	Ceftriaxone	6,6	Bolus	Dobutamine HCL	2,5-5,5	Infusion*	6	Acid pH Difference
4	Ketorolac Tremethamine	6,9-7,9	Bolus	Midazolam HCL	2,5-4	Infusion*	11	Acid pH Difference
5	Ketorolac Tremethamine	6,9-7,9	Bolus	Nicardipine HCl	3,2-4,2	Infusion*	3	Acid pH Difference
6	Ketorolac Tremethamine	6,9-7,9	Bolus	Levofloxacin	3,8-5,8	Infusion	3	Acid pH Difference
7	Ketorolac Tremethamine	6,9-7,9	Bolus	Rocuronium Bromida	4	Bolus	8	Acid pH Difference
8	Ceftriaxone	6,6	Bolus	Magnesium SO4	5,5-7	Bolus	5	Acid pH Difference
9	Acetaminophen	5 – 5,5	Infusion	Metronidazole	4,5-7	Infusion	2	Acid pH Difference
10	Ketamine HCl	3,5-5,5	Bolus	Rocuronium Bromida	4	Bolus	6	Acid pH Difference
11	Amiodarone HCL	4,08	Infusion*	Levofloxacin	3,8-5,8	Infusion	2	Acid pH Difference
12	Epinephrine HCL	2,2-5	Infusion*	Voluven	4-5,5	Infusion	1	Acid pH Difference
13	Midazolam HCL	2,5-4	Infusion*	Albumin	4-7,4	Infusion	8	Acid pH Difference
	Frequency of incompatibility						57	
	Number of IV couple incompatibilities						13	

Infusion* = Administration via Syringe pump

To prevent incompatibility in administering the above drug pairs, infusion drugs are administered in the following manner: 1) In the same vein using a multilumen central venous catheter (CVC) with the administration of the first acidic drug infusion/bolus and the second acidic drug infusion/bolus in separate lumens so as to prevent contact between the two drug pairs due to differences in acid pH; 2) In the same vein using a monolumen central venous catheter (CVC) with a delivery partner: a) infusion of the first acid drug and bolus of the second acid drug, then the administration is carried out with an on-off and flushing system with the following sequence; turn off the three-way tap of the first acid drug infusion, flush with 5% Glucose fluid, inject the second acid drug bolus, flush with 5% Glucose fluid again and turn on the three-way tap of the first acid drug infusion. This on-off system can prevent the occurrence of bolus-infusion incompatibility in the three way and extension tube; b) The first acidic drug bolus and the second same drug bolus then flushing is performed. If the first acidic drug bolus is given, flushing is done with 5% Glucose solution, injecting the first acidic drug bolus, flushing with 5% Glucose solution then followed by injecting the second acidic drug bolus and flushing with 5% Glucose solution again; 3) In two different veins using peripheral intravenous catheters (PIVCs) where one vein is used to administer the first infusion/bolus of acid medication and the other vein is used to administer the second infusion/bolus of acid medication.

f. Incompatibility of intravenous injection partners of basic drugs based on differences in base pH. The results of the identification of incompatibility of intravenous injection drug pairs based on differences in alkaline pH obtained 7 pairs with a frequency of 12 times.

Table 9. Incompatibility of drug pairs based on differences in base pH

No	Administration of intravenous injection base drug pairs based on the difference in pH of the base							Information
	Alkaline Medicine	pH	Giving	Alkaline Medicine	pH	Giving	Amount	
1	Furosemide	8-9,3	Infusion*	Lansoprazole	11	Bolus	2	Base pH Difference
2	Furosemide	8-9,3	Infusion*	Phenytoin Sodium	12	Bolus	1	Base pH Difference
3	Insulin Reguler	7-7,8	Infusion*	Phenytoin Sodium	12	Bolus	1	Base pH Difference

4	Lansoprazole	11	Bolus	Phenytoin Sodium	12	Bolus	1	Base pH Difference
5	Meropenem	7,3-8,3	Bolus	Phenytoin Sodium	12	Bolus	4	Base pH Difference
6	Methylprednisolone Sodium Succinate	7-8	Bolus	Phenytoin Sodium	12	Bolus	1	Base pH Difference
7	Dexamethasone Sodium Phorpahte	7-8,5	Bolus	Phenytoin Sodium	12	Bolus	12	Base pH Difference
		Frequency of incompatibility					12	
		Number of IV couple incompatibilities					7	

Infusion* = Administration via Syringe pump

To prevent incompatibility in administering the above drug pairs, infusion drugs are administered in the following manner: 1) In the same vein using a multilumen central venous catheter (CVC) with the administration of an infusion/bolus of the first base drug and an infusion/bolus of the second base drug in separate lumens so as to prevent contact between the two drug pairs due to differences in acid pH; 2) In the same vein using a monolumen central venous catheter (CVC) with a delivery partner: a) infusion of the first base drug and bolus of the second base drug, then the administration is carried out with an on-off and flushing system with the following sequence; turning off the three-way tap for the first base drug infusion, flushing with 0.9% NaCl fluid, injecting the second base drug bolus, flushing with 0.9% NaCl fluid again and turning on the three-way tap for the first base drug infusion. This on-off system can prevent the occurrence of bolus-infusion incompatibility in the three way and extension tube; b) The first base drug bolus and the second base drug bolus are then flushed. To administer the first base drug bolus, flush with 0.9% NaCl solution, inject the first base drug bolus, flush with 0.9% NaCl solution, then inject the second base drug bolus and flush again with 0.9% NaCl solution; 3) In two different veins using peripheral intravenous catheters (PIVCs) where one vein is used to administer the first base infusion/bolus of medication and the other vein is used to administer the second base infusion/bolus of medication.

2. Incompatibility of intravenous injection partners based on ion reaction mechanisms. The results of the identification of incompatibility of intravenous injection drug pairs obtained 3 pairs with a frequency of 6 times where the ion reaction of two drugs that have a charge where drug precipitation occurs due to ion exchange from one drug to an ion from another drug forming an insoluble salt (Mendel et al., n.d.). Large anions and cations can form precipitation or insoluble complexes (Maharani L et al 2013). In this survey, if the drug ceftriaxone interacts with calcium gluconate, ringer lactate or TNA 3 in 1 total nutrients/Kabiven containing Calcium, calcium-ceftriaxone deposits will form.

Tabel 10. Inkompatibilitas berdasarkan reaksi ion obat injeksi intravena

No	Intravenous injection drug incompatibility pair					Amount
1	Ceftriaxone	Bolus	Calcium Gluconate	Bolus		1
2	Ceftriaxone	Bolus	Ringer injeksi (Ca)	Infusion		3
3	Ceftriaxone	Bolus	TNA 3 in 1 total nutrien / Kabiven (Ca)	Infusion		2
	Frequency of incompatibility					6
	Number of incompatibilities of intravenous injection drug pairs					3

To prevent incompatibility of administration of ceftriaxone injection drug pairs with intravenous injection of calcium gluconate, Ringer lactate or TNA 3 in 1 (Kabiven) containing calcium, it should not be mixed either when administered via the same or different routes in patients within 48 hours because ceftriaxone has a long half-life in the body, and according to recommendations from Health Canada in July 2008 for children born at 10 weeks should not be given a combination of ceftriaxone with intravenous injection containing calcium for less than 5 days (Gin & Walker, 2009; Reid-Searl et al., 2009). If intravenous injection containing calcium is required, it is necessary to substitute/replace the appropriate antibiotic.

3. Incompatibility of intravenous injection partners based on the mechanism of gas/bubble formation reactions. The results of the identification of incompatibility of intravenous injection drug pairs obtained 8 pairs with a frequency of 27 times where the reduction and oxidation reactions between the two drugs after mixing caused the appearance of bubbles or foam. In this gas survey, carbon dioxide gas was formed from the reaction between sodium bicarbonate and salt.

Table 11. Incompatibility based on gas/bubble formation reactions of intravenous injection drugs

No	Intravenous injection drug incompatibility pairs				Amount
1	Sodium Bicarbonate	Bolus	Dobutamin HCl	Infusion*	3
2	Sodium Bicarbonate	Bolus	Dopamin HCl	Infusion*	1
3	Sodium Bicarbonate	Bolus	Epinephrine HCl	Infusion*	5
4	Sodium Bicarbonate	Bolus	Ketamine HCL	Bolus	5
5	Sodium Bicarbonate	Bolus	Lansoprazole	Bolus	1
6	Sodium Bicarbonate	Bolus	Midazolam HCL	Infusion*	4
7	Sodium Bicarbonate	Bolus	Norepinephrine bitartrate	Infusion*	7
8	Sodium Bicarbonate	Bolus	Ondansetrone HCL	Bolus	1
	Frequency of incompatibility				27
	Number of incompatibilities of intravenous injection drug pairs				8

Infusion* = Administration via Syringe pump

To prevent incompatibility in administering the above drug pairs, the drugs are administered in the following manner: a) In the same vein using a multilumen central venous catheter (CVC) with bolus administration of sodium bicarbonate on a separate line from other acidic drugs, either bolus/infusion; b) In the same vein using a monolumen central venous catheter (CVC): 1. infusion of acidic drugs and bolus of sodium bicarbonate drugs, the administration is carried out with an on-off and flushing system with the following sequence; turning off the three-way tap for acidic drug infusion, flushing with 0.9% NaCl fluid, injecting a bolus of sodium bicarbonate drugs, flushing with 0.9% NaCl fluid again and turning on the three-way tap for acidic drug infusion. This on-off system can prevent the occurrence of bolus-infusion incompatibility in the three way and extension tube; 2. bolus of acidic drugs and bolus of sodium bicarbonate drugs, then flushing is performed. To administer bolus of acidic drugs, flush with 5% Dextrose solution, inject bolus of acidic drugs, flush with 5% Dextrose solution, then inject bolus of sodium bicarbonate drugs and flush with 0.9% NaCl solution.

4. Incompatibility of intravenous injection partners based on the mechanism of broken/ruptured emulsion. The results of the identification of incompatibility of intravenous injection drug pairs obtained 7 pairs with a frequency of 20 times where the rupture of the emulsion will cause the formation of globules that are larger than the emulsion carrier. In this survey, the coating and merging of propofol carriers is caused by the rupture of the emulsifier and the reduction of electrostatic repulsion.

Table 12. Incompatibility based on damage/breakage of intravenous injection drug emulsion

No	Intravenous injection drug incompatibility pair				Amount
1	Acetaminophen	Infusion	Propofol	Bolus	6
2	Amikacin SO4	Bolus	Propofol	Bolus	2
3	Gentamicin SO4	Bolus	Propofol	Bolus	1
4	Albumin	Bolus	TNA 3 in 1 total nutrien/Kabiven	Infusion	3
5	Levofloxacin	Infusion	Propofol	Bolus	4
6	Methylprednisolone Sodium Succinate	Bolus	Propofol	Bolus	1
7	Metronidazole	Infusion	Propofol	Bolus	3
	Frequency of incompatibility				20
	Number of incompatibilities of intravenous injection drug pairs				7

To prevent incompatibility in administering the above drug pairs, propofol emulsion injection or TNA 3 in 1 should not be mixed with infusion in one container or at the y-site, it should

be administered intravenously directly into a large vein using a multilumen central venous catheter (CVC).

5. Incompatibility of intravenous injection partners due to dilution of injections made with mixed solvents. The results of the identification of incompatibility of intravenous injection drug pairs obtained 18 pairs with a frequency of 31 times where precipitation during dilution was caused by the formation of intermolecular hydrogen bonds between water and alcohol molecules, resulting in a reduction in van der Waals forces which are weaker than alcohol to dissolve drug molecules. In this survey, diazepam injection drugs formulated with alcohol solvents and mixed with lactate ringer infusion will precipitate due to decreased solubility due to the presence of electrolytes.

Table 13. Incompatibility of intravenous injection partners due to dilution of injections made with mixed solvents

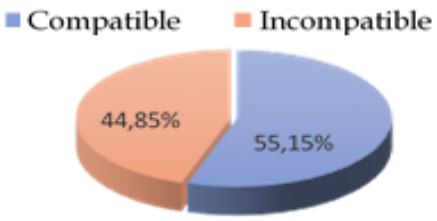
No	Intravenous injection drug incompatibility pair				Amount
1	Diazepam	Bolus	Ceftriaxone	Bolus	1
2	Diazepam	Bolus	Dexamethasone Sodium Phorpahte	Bolus	1
3	Diazepam	Bolus	Epinephrine HCl	Infusion*	2
4	Diazepam	Bolus	Furosemide	Infusion*	1
5	Diazepam	Bolus	Lansoprazole	Bolus	1
6	Diazepam	Bolus	Levofloxacin	Infusion	1
7	Diazepam	Bolus	Meropenem	Bolus	1
8	Diazepam	Bolus	Midazolam HCL	Infusion*	1
9	Diazepam	Bolus	Nicardipine HCl	Infusion*	1
10	Diazepam	Bolus	Norepinephrine bitartrate	Infusion*	2
11	Diazepam	Bolus	Phytomenadion	Bolus	1
12	Diazepam	Bolus	Phenytoin Sodium	Bolus	2
13	Diazepam	Bolus	Ringer Lactat	Infusion	1
14	Diazepam	Bolus	Insulin Regular	Infusion*	1
			Frequency of incompatibility		17
			Number of incompatibilities of intravenous injection drug pairs		14

Infusion* = Administration via Syringe pump

To prevent incompatibility in administering the above drug pairs, diazepam injection should be given intravenously directly into a large vein using a multilumen central venous catheter (CVC) and should not be mixed with other injectable drugs or added to intravenous fluids.

Results of identification of patients receiving electronic prescriptions

From the results of a survey conducted in the ICU room of Dr. Pirngadi Hospital, Medan City, data was obtained on 165 patients who received electronic prescriptions for intravenous injection drugs, with 91 patients receiving compatible prescriptions and 74 patients receiving incompatible prescriptions. Graph 1.



Graph 1. Patient Electronic Prescribing

General Strategies for Preventing Incompatibility in Intravenous Injection Drug Administration in Hospitals

In order to prevent incompatibility of intravenous injection drug pairs when given together in hospital, several strategies need to be developed:

a) Table of intravenous injection drug administration routes based on acid administration routes, base administration routes and special routes to prevent drug interaction/contact at the injection site, both on the three-way connector and on the extension tube.

Table 14. Recommendations for intravenous injection drug administration routes to prevent incompatibility

No	Acid Track	pH	Basal Path	pH	Special Lane	pH
1	Acetaminophen	5 - 5,5	Calcium Gluconate	6.-8,2	Albumin	4-7,4
2	Amikacin SO4	3,5-5,5	Dexamethasone Sodium Phorpahte	7-8,5	Diazepam	6,2-6,9
3	Amiodarone HCL	4,08	Furosemide	8-9,3	Phenytoin Sodium	12
4	Atropine Sulfate	3-3,65	Insulin Regular	7-7,8	Propofol	7-8,5
5	Azithromicin	6,4-6,6	Ketorolac Tremethamine	6,9-7,9	TNA 3 in 1 total nutrien / Kabiven	5-7
6	Ceftazidine	5-8	Lansoprazole	11	Voluven	4-5,5
7	Ceftriaxone	6,6	Meropenem	7,3-8,3		
8	Ciprofloxacin	3,3-3,9	Methylprednisolone Sodium Succinate	7-8		
9	Dobutamine HCL	2,5-5,5	Omeprazole Na	9-10,5		
10	Dopamin HCl	2,5-5,5	Phenobarbital	9,2-10,2		
11	Epinephrine HCl	2,2-5	Sodium Bicarbonate	7-8,5		
12	Fentanyl Sitrat	4-7,5				
13	Gentamicin SO4	3-5,5				
14	Ketamine HCL	3,5-5,5				
15	Levofloxacin	3,8-5,8				
16	Levofloxacin	3,8-5,8				
17	Magnesium SO4	5,5-7				
20	Metochlorpramide HCL	4,5-6,5				
28	Metronidazole	4,5-7				
29	Midazolam HCL	2,5-4				
30	Midazolam HCL	2,5-4				
31	Moxifloxacin HCL	5-6				
32	Nicardipine HCl	3,2-4,2				
33	Norepinephrine bitartrate	3-4,5				
34	Ondansetrone HCL	3-4				
35	Phytomenadion	3,5-7				
36	Potasium Chlorida/KCL	4-8				
37	Pyridoxine HCl	2-3,8				
38	Ranitidine HCl	6,7-7,3				
39	Ringer Lactat	6-7,5				
40	Rocuronium Bromida	4				

b) Creation of an electronic identification application for incompatible prescriptions of intravenous injection drug pairs in the hospital information system.

c) The creation of standard operating procedures for mixing techniques to prevent incompatibility in the simultaneous administration of intravenous injection drug pairs can be implemented as in Figure 1 below.

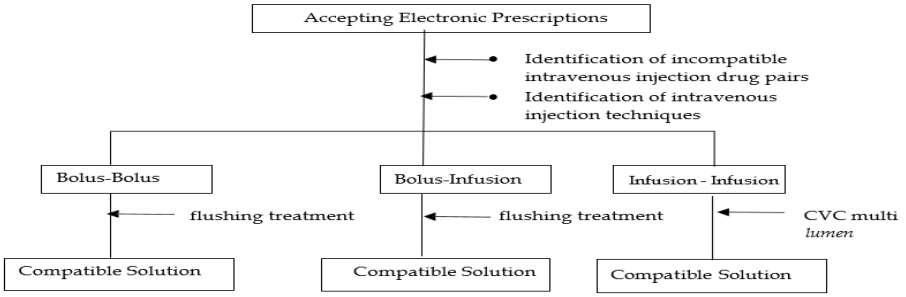


Figure 1. Standard operating procedure for preventing incompatibility in administering intravenous injection drug pairs in hospitals

CONCLUSION

Incompatibility survey using Lexicomp® application electronic prescription of intravenous injection drug pairs in ICU retrospectively still many patients receive incompatible prescriptions conducted on 165 patients in ICU there were 91 patients received compatible prescriptions and 74 patients received incompatible prescriptions consisting of 70 incompatible drug pairs consisting of acid-base reactions 50 pairs, acid pH changes 13 pairs, base pH changes 12 pairs, dilution of mixed solvents 14 pairs, gas/bubble formation 8 pairs, broken/damaged emulsions 7 pairs and ion reactions 3 pairs. In the simultaneous administration of incompatible drug pairs through the same intravenous route, flushing treatment can be applied with compatible solutions before and after drug administration and using multi-lumen CVC and using peripheral intravenous catheters (PIVC) administration of different intravenous routes can prevent incompatibility of injection drugs. These findings suggest that intravenous drug mismatches in ICU administration practices are still common, particularly due to interactions based on pH differences, ion reactions, emulsions, and mixed solvents. Therefore, the results of this study can be used to develop case-based training modules that emphasize the introduction of incompatibility mechanisms (e.g. acid-base reactions, emulsion breakdown, gas formation), simulation of correct drug administration practices using different infusion lines (multi-lumen) and flushing techniques. Some systemic recommendations that can be implemented include the integration of automatic incompatibility detection features in hospital e-prescribing systems (SIRS), by utilizing databases such as Lexicomp in real-time and standardization of SOPs for intravenous drug administration in the ICU, especially regarding the on-off-flush technique and the use of separate infusion lines.

References

Abdelkader, A., Fathi, H. A., Hamad, M. A., & Elsabahy, M. (2020). Nanomedicine: a new paradigm to overcome drug incompatibilities. *Journal of Pharmacy and Pharmacology*, *72*(10), 1289–1305.

Akbar, F. (2020). *Perbandingan Pengaruh Pemberian Terapi Kombinasi (Anestesi Lokal Dan Analgesik Intravena) Dengan Monoterapi (Analgesik Intravena) Terhadap Tingkat Nyeri Pasca Operasi Sectio Caeasaria Di Rs Siti Khodijah Sepanjang*. Universitas Muhammadiyah Surabaya.

Alvarez-Nunez, F. A., & Yalkowsky, S. H. (1999). Buffer capacity and precipitation control of pH solubilized phenytoin formulations. *International Journal of Pharmaceutics*, *185*(1), 45–49.

Anderson, C., Boehme, S., Ouellette, J., Stidham, C., & MacKay, M. (2014). Physical and chemical compatibility of injectable acetaminophen during simulated y-site administration. *Hospital Pharmacy*, *49*(1), 42–47.

Bernaerts, K., Evers, G., & Sermeus, W. (2000). Frequency of intravenous medication administration to hospitalised patients: secondary data-analysis of the Belgian Nursing Minimum Data Set. *International Journal of Nursing Studies*, *37*(2), 101–110.

D'Huart, E., Vigneron, J., & Demoré, B. (2019). Physical compatibility of intravenous drugs commonly used in intensive care units: an observational study and physical compatibility laboratory tests on anti-infective drugs. *Pharmaceutical Technology in Hospital Pharmacy*, *4*(1), 29–40.

Fahimi, F., Ariapanah, P., Faizi, M., Shafaghi, B., Namdar, R., & Ardakani, M. T. (2008). Errors in preparation and administration of intravenous medications in the intensive care unit of a teaching hospital: an observational study. *Australian Critical Care*, *21*(2), 110–116.

Gin, A., & Walker, S. (2009). Notice to Hospitals Regarding Ceftriaxone–Calcium Incompatibility: What'sa Clinician to Do? *The Canadian Journal of Hospital Pharmacy*, *62*(2), 157.

Hanifah, S. (2015). IDENTIFIKASI pH OBAT-OBAT YANG DIGUNAKAN DI PEDIATRIC INTENSIVE CARE UNIT (PICU) UNTUK PENCEGAHAN INKOMPATIBILITAS INTRAVENA. *Jurnal Ilmiah Farmasi*, *11*(2), 55–64.

Hanifah, S. (2020). *Stabilitas dan Kompatibilitas Injeksi Propofol Sebagai Anestesi Umum di Rumah Sakit: Tinjauan Sistematis*.

Kanji, S., Goddard, R., Donnely, R., McIntyre, L., Turgeon, A., & Coons, P. (2010). Physical compatibility of drug infusions used in Canadian Intensive Care Units: a program of research. *Crit Care Med*, *38*(9), 1890–1898.

Maharani, L., Astuti, A. W., & Achmad, A. (2014). Kompatibilitas pencampuran sediaan parenteral di bangsal

bedah saraf RSUD Prof. Dr. Margono Soekarjo. *Jurnal Farmasi Klinik Indonesia*, *3*(1), 1–9.

Mendel, Y., Kaisermann, J., & Pawlowski, M. (n.d.). *Teknik Biologi Molekuler II*. Cambridge Stanford Books.

Mosisa, B., Negeri, B., Bayisa, G., Sado, E., Fekadu, G., Gebre, M., Gamachu, B., & Sudhakar, S. (2020). Assessment of Intravenous Drugs Admixtures Incompatibilities at Nekemte Referral Hospital, West Ethiopia. *American Journal of Health Research*, *8*(5), 84–88.

MOUDYTA, K. (2021). *FORMULASI MASKER GEL PEEL-OFF EKSTRAK ETANOL DAUN PANDAN WANGI (Pandanus amaryllifolius Roxb) SEBAGAI ANTIOKSIDAN*. Universitas Perintis Indonesia.

Nurseta, T., Samsu, N., Perdhana, R., Palapa, H., Anggraeni, F. R., Wicaksono, B. A., Nugraha, N., & Gandhari, A. A. S. A. A. (2022). *Kemoterapi Pada Kanker Ginekologi*. Universitas Brawijaya Press.

Okuyama, A., Wagner, C., & Bijnen, B. (2014). Speaking up for patient safety by hospital-based health care professionals: a literature review. *BMC Health Services Research*, *14*, 1–8.

Rahmawati, R., Rahmawati, F., & Sulaiman, S. A. S. (2018). Problem Kompatibilitas dan Stabilitas Pencampuran Sediaan Intravena Pada Pasien Anak di RSUP Dr. Sardjito. *Jurnal Farmasi (Journal of Pharmacy)*, *7*(1), 19–23.

Reid-Searl, K., Moxham, L., Walker, S., & Happell, B. (2009). Internal conflict: Undergraduate nursing students' response to inadequate supervision during the administration of medication. *Collegian*, *16*(2), 71–77.

Setiawati, M. C. N., & Munisih, S. (2023). Incompatibility Profile of Intravenous Drug Preparations for Intensive Care Unit Patients at'X'Hospital Semarang for the period January-June 2022. *Jurnal Penelitian Farmasi Indonesia*, *12*(2), 60–64.

Setyani, W., & Putri, D. C. A. (2020). *Resep dan Peracikan Obat*. Sanata Dharma University Press.

Syahbarni, S., Setiawati, M. C. N., & Ningrum, E. P. (2021). Gambaran Kompatibilitas Sediaan Obat Intravena Dengan Sediaan Lain Pada Pasien Di ICU. *Media Kesehatan Politeknik Kesehatan Makassar*, *16*(1), 83–89.

Taxis, K., & Barber, N. (2004). Incidence and severity of intravenous drug errors in a German hospital. *European Journal of Clinical Pharmacology*, *59*, 815–817.

Ulfa, A. M. (n.d.). BAB 3 BAHAN TAMBAHAN DALAM SEDIAAN CAIR. *BAHAN TAMBAHAN SEDIAAN FARMASI*, 21.

Vijayakumar, A., Sharon, E. V, Teena, J., Nobil, S., & Nazeer, I. (2014). A clinical study on drug-related problems associated with intravenous drug administration. *Journal of Basic and Clinical Pharmacy*, *5*(2), 49.

WHO. (2017). *Global Patient safety challenge. medication without harm*. Geneva: World Health Organization.

YULIANI, I. K. A. A. N. I. (2021). *PENGARUH VARIASI KONSENTRASI PROPILENGLIKOL DAN PVA TERHADAP STABILITAS MASKER PEEL OFF EKSTRAK KULIT JENGKOL*. Stikes Karya Putra Bangsa Tulungagung.