

Tubing Misconnections: Making the Connection to Patient Safety

ABSTRACT

Some patients may have multiple tubing lines connected to them for reasons such as delivery of medication and nutrition therapy. With these multiple lines, the potential for tubing misconnections becomes more prevalent. Tubing misconnections can occur with intravenous catheters, feeding tubes, hemodialysis tubes, and tracheostomy cuffs, among other devices. One of the main reasons for tubing misconnections is that many types of tubing for different types of medical devices incorporate luer connectors. These connectors contribute to misconnections because they allow functionally dissimilar tubes or catheters to be connected together. Between January 2008 and September 2009, 36 events of tubing misconnections were reported to the Pennsylvania Patient Safety Authority involving various types of misconnections. Methods for reducing the likelihood of tubing misconnections include equipment design solutions and administrative controls (policies and work practices). Equipment design solutions either prevent the user from making a misconnection or prompt the user to make the correct connection. Administrative controls are policies and practices that reduce the risk of misconnections such as tracing lines back to their source. (*Pa Patient Saf Advis* 2010 Jun;7[2]:41-5.)

Introduction

Depending on acuity level, patients may have many tubing lines connecting them to medical devices and/or for delivering medication or nutrition therapy. Medical devices connected to patients may also have tubing lines connecting the devices with other medical devices. Under these circumstances, tubing misconnections can occur with potentially fatal results. Misconnections have been recognized as a serious problem for many years. One of the earliest published reports of misconnections was the inadvertent delivery of breast milk via intravenous (IV) administration in 1972.¹ However, misconnections have garnered more attention in recent years, especially in the United States, due in part to the tubing misconnection *Sentinel Event Alert* issued by the Joint Commission in April 2006.²

The *Sentinel Event Alert* describes the types of tubing and catheter misconnections reported to Joint Commission, including central intravenous catheters, peripheral intravenous catheters, nasogastric feeding tubes, tracheostomy cuff inflation tubes, and automatic blood pressure cuff insufflation tubes. The *Alert* also described misconnection events reported to U.S. Pharmacopeia (USP), including intravenous infusions connected to epidural lines and infusions intended

for IV delivery connected to nasogastric tubes.² The *Alert* offers risk reduction strategies and recommendations, which are included in the overall risk reduction strategies below.

There are many types of misconnections; however, this article will focus on liquid-to-liquid and liquid-to-gas misconnections because these misconnections can pose the most serious harm to patients and are the most frequently reported to the Pennsylvania Patient Safety Authority. Liquid lines are typically those that administer medications or nutrition but can also include solution lines such as flush lines. Medical gas lines are typically used for respiratory support or to power pneumatic medical devices. Liquid-to-liquid misconnections can result in a liquid substance entering the wrong body part or the wrong substance entering the patient. Liquid-to-gas misconnections are incorrect connections that can result in gas introduced into patients' blood vessels or liquid entering patients' respiratory tracts.³

A common reason for tubing misconnections, whether liquid-to-liquid or liquid-to-gas, is that many types of tubing lines for different medical devices incorporate common luer connectors. The International Organization for Standardization (ISO) characterizes a luer connector as a conical fitting with a 6% (luer) taper for syringes, needles, and other medical equipment.⁴ The luer connection system consists of male and female counterparts that are joined together either by push (luer slip) or screw-in threaded (luer lock) fittings. Luer connectors contribute to misconnections because they easily allow functionally dissimilar tubes or catheters to be connected together.²

Misconnections in Pennsylvania

Between January 2008 and September 2009, 36 tubing misconnection events were reported to the Authority: 35 liquid-to-liquid events and 1 liquid-to-gas event. (See the Table for a breakdown of the types of misconnections reported.) Examples of the Serious Events and Incidents involving misconnections reported to the Authority include the following:

The patient is a 4-week-old infant admitted . . . to determine need for surgery. The physician ordered a 75 ml bolus of NS [normal saline]. A . . . nurse connected the bag of NS at the patient's lower "Y" site and set the pump correctly. 500 ml of the NS was administered over 30 minutes . . . [because the connection bypassed the infusion pump].

The physician found the feeding tube connected to the G-tube and the J-tube connected to suction in error . . . Tubes were corrected . . .

The patient had both an epidural and PCA [patient-controlled analgesia]. Investigating a case

Table. Tubing Mismconnections Reported to the Pennsylvania Patient Safety Authority, January 2008 to September 2009

MISCONNECTION	NUMBER OF REPORTS
Secondary intravenous (IV) infusion connected to lower "Y" port of primary IV tubing set	8
Hemodialysis arterial and venous tubing lines reversed	5
G-tube and J-tube lines reversed	3
Incorrect tubing connection (no further explanation provided in reports)	3
Epidural and patient-controlled analgesia (PCA) tubing sets reversed	2
Nonhemodialysis arterial and venous tubing lines reversed	2
Cell saver tubing connected to cell saver reservoir	1
Feeding tube set connected to Broviac®	1
Feeding tube set connected to peripherally inserted central catheter (PICC) line	1
Feeding tube set connected to suction port	1
Imaging contrast tubing set connected to tracheostomy cuff	1
IV tubing set connected to dialysis catheter	1
IV tubing set connected to PICC line	1
IV tubing set connected to tracheostomy cuff	1
Knee irrigation connected to peripheral IV tubing	1
Miscommunication (arterial line noted in medical record as peripheral IV)	1
Oral medication delivered through peripheral IV line	1
Suction line connected to water seal	1
Suction and feeding tubing sets reversed	1
Total	36

of pain . . . The tubings [sic] were connected incorrectly, and the patient received one narcotic epidural (ordered via PCA) and the other narcotic via PCA (ordered via epidural).

Patient arrived at MRI [magnetic resonance imaging] suite for an abdominal study. Subclavian catheter and tracheostomy to be present and all ports having similar injection valves [sic]. The technologist was scanning, and the anesthesiologist connected the injector tubing attached to the patient's IV site. Contrast and saline were injected. The scan showed no signs of contrast. The patient was then pulled out of the MRI, and [it was] discovered that the contrast was injected into the tracheostomy cuff.

The patient, status post thoracoabdominal surgery, had a Jackson Pratt and sump drain inserted into the mediastinal cavity. The patient also had a jejunal feeding tube placed. Upon assessment of the patient's Jackson Pratt drain, it was noted that it was draining a whitish substance which was determined to be the tube feeding. The physician was notified and discovered that the tube feeding was connected to the sump instead of the jejunal feeding tube . . .

Wrong route: connect[ed] a 1000 cc bag to a peripheral site when the bag was intended for knee irrigation.

Prevention Methods

Two methods for reducing or eliminating mismconnections are addressing equipment design and developing or revisiting hospital policies and work practices. National and international standards address connec-

tor design to minimize mismconnections; however, for many technologies, these standards have been neither widely adopted nor fully successful.³ One standard, currently in draft form, by the Association for the Advancement of Medical Instrumentation (AAMI) and ISO,* will aim to reduce mismconnections by addressing design requirements for small bore connectors for liquids and gases in healthcare applications. This standard will propose development of alternative, non-interconnectable, small bore connectors for various healthcare applications. The AAMI/ISO small bore standard is expected to be finalized by early 2010.³

When equipment designs to prevent mismconnections are unavailable, healthcare facilities must rely on hospital policies and work practices, also referred to as administrative controls, to minimize mismconnections. An example of an administrative control is a policy to trace all lines back to their origin before a connection is made. Another example is limiting the use of adapters to those that are necessary for a specific application.³ Mismconnections can occur when incorrectly using adapters to connect two or more devices together that would not normally pair.

Equipment design solutions, especially forcing functions, are more effective in reducing or eliminating mismconnections than administrative controls. A forcing function design impels an individual to make the correct decision or connection. An example of a forcing function commonly cited in literature is the

* AAMI/ISO 80369-01 1ed. *Small bore connectors for liquids and gases in healthcare applications—part 1: general requirements.*

gear shift of an automobile. In newer automobile designs, the gear shift cannot be moved from the park to the reverse position until the operator first depresses the brake pedal.

However, neither equipment design solutions nor administrative controls alone are sufficiently effective. Equipment design solutions exist for some devices but are not widely available, and ensuring that staff always make the correct connection is impractical.³ Additionally, even well-designed equipment safety features can be circumvented by untrained individuals or those who do not fully understand the risks associated with defeating the features.³ Using equipment designs and administrative controls together is the optimal approach in reducing misconnection risks. When possible, healthcare facilities could purchase equipment with misconnection safety features such as nonluer connectors on tubing used with nonintra-venous devices (e.g., nebulizers) and institute appropriate policies and work practices as part of a misconnection mitigation action plan.

Tubing Misconnections Risk Reduction Strategies

The following misconnection risk reduction strategies include incorporating equipment design solutions and hospital policies and work practices.^{2,3} The lists are separated into strategies for clinical staff and nonclinical staff. Nonclinical staff include patient safety, clinical/biomedical engineering, risk management, purchasing (materials management) personnel, patients, and visitors.³ (Risk reduction strategies specific to enteral feeding misconnections are listed separately.)

Clinical Staff^{2,3}

- Trace all lines back to their point of origin to verify that correct connections are made. While this step increases a clinician's time with a patient, it is a necessary step in preventing misconnections.
- Recheck connections and trace all lines to their point of origin after the patient's arrival to a new care area or as part of a handoff process.
- Do not force connections. If a great amount of effort is needed to make a connection, then there is a good chance that the connection should not be made.
- Only use adapters that are clearly indicated for a specific application. Additionally, the need for an adapter may mean that the connection should not be made.
- Label certain high-risk catheters as to the type of catheter (e.g., epidural, intrathecal, arterial).
- Route lines (e.g., tubes, catheters) with different purposes in unique and standardized directions (e.g., route IV lines toward the patient's head, route enteral feeding lines toward the patient's feet).
- Identify and manage conditions that may contribute to worker fatigue, which could result in

inattentiveness when making tubing connections, and take appropriate action.

Nonclinical Staff^{2,3}

- Provide regular misconnection prevention education, emphasizing the risk of misconnections, to all personnel working in patient care environments. Include nonclinical personnel (e.g., housekeeping), patients, and visitors in the training process. For example, explain the need to request help rather than attempting to disconnect or reconnect lines.
- Assess the need for adapters throughout the facility, and limit or restrict their routine use. Adapter assessment should be performed by a multidisciplinary team that includes nursing, risk management, clinical/biomedical engineering, and purchasing personnel.
- Revise and/or establish purchasing policies that include, when possible, purchasing equipment with misconnection safeguards. For example, avoid purchasing nonintra-venous equipment (e.g., non-invasive blood pressure devices) that can mate with female luer IV connectors.
- Perform prepurchase evaluations and acceptance testing for safety and efficacy on tubing and catheters, as appropriate, to assess the potential for misconnections.

Enteral Feeding Misconnections Risk Reduction Strategies

Enteral feeding is the delivery of nutrients through a tube for patients who have a functioning gastrointestinal tract but cannot orally receive food and nutrition due to a health condition. Misconnections during enteral feeding typically include one of the two following scenarios:³

1. Nutrients intended for the gastrointestinal (GI) tract are inadvertently delivered elsewhere (e.g., vascular system).
2. Inappropriate fluids (e.g., IV solutions) are inadvertently delivered to the GI tract.

The first type of misconnection listed above (nutrients for GI tract delivered elsewhere) can have the most serious consequence for patients. Death can easily result due to embolus or sepsis.³ The Joint Commission *Sentinel Event Alert* describes a few enteral misconnection errors such as enteral feeding tubes connected to central venous catheters, enteral feeding tubes connected to hemodialysis lines, and infusions intended for IV delivery connected to nasogastric tubes, among others.²

The methods for preventing enteral feeding misconnections are similar to those for preventing other tubing misconnections: equipment design solutions and policies and work practices. As with other tubing, there are no standards for universal connector designs unique to enteral feeding devices and sets.³ However, there are currently a few enteral feeding systems that incorporate designs addressing misconnection

safeguards. The lists are also separated into strategies for clinical and nonclinical staff.

Clinical Staff^{2,3}

- Do not use standard luer syringes for oral medications or enteral feedings.
- Prohibit modifying or adapting IV or enteral feeding devices. Modifying devices may jeopardize design safety features.
- Route lines with different purposes in unique and standardized directions (e.g., route IV lines toward the patient's head, route enteral feeding lines toward the patient's feet).
- Identify and manage conditions that may contribute to worker fatigue, which could result in inattentiveness when making tubing connections, and take appropriate action.
- Review identification labels before administering solutions to ensure that the intended delivery route is correct. The solution's appearance alone is not an adequate method for identification because enteral formulas may resemble some IV solutions that have milky appearances (e.g., lipid-containing solutions). Properly identifying the correct solution prior to administering reduces the risk that an enteral container will be mistakenly spiked with an IV administration set. Placing labels with warnings such as "WARNING! For Enteral Use Only—Not for IV Use" may also reduce the likelihood of a misconnection.

In the U.S. Pharmacopeia Medication Safety Forum position statement, labeling or color-coding feeding tubes and connectors and educating staff on the labeling or color-coding system were suggested as a risk reduction strategy.⁵ However, in the tubing misconnection *Sentinel Event Alert*, Joint Commission acknowledges this risk reduction approach, but noted the following potential unintended consequences if implemented:²

- Users may rely on color-coding rather than assuring a clear understanding of correct connections between tubes or catheters and body inlets.
- Continual attention to education and training of the color-coding system will be needed for staff, including temporary and travel staff.

- Various color-coding systems may be used across facilities within the same geographic area, which could lead to confusion particularly for temporary and travel staff.

Nonclinical Staff^{2,3}

- Ensure that an adequate number of distinctly labeled enteral pumps are purchased to reduce or eliminate the use of infusion pumps for enteral administration to adult patients. When using syringe pumps for neonatal feedings, ensure that the pumps are clearly distinct from syringe pumps used for IV administration or other medical purposes. However, a more reliable approach is using enteral pumps for neonatal feedings, except if using nonluer tubing technologies.
- Establish or reinforce existing purchasing policies that mandate purchasing only enteral feeding sets that are incompatible with female luer connectors.
- Purchase only non-IV-compatible enteral feeding containers.
- Secure enteral administration sets with enteral feeding containers (e.g., with rubber band) or use preattached sets (e.g., from the manufacturer) before sending them to the patient care unit.
- Perform prepurchase evaluations of enteral feeding systems under the guidance of a multidisciplinary task force before purchasing decisions are made.

Notes

1. Wallace JR, Payne RW, Mack AJ. Inadvertent intravenous infusion of milk. *Lancet* 1972 Jun 10:1264-66.
2. Joint Commission. Tubing misconnections—a persistent and potentially deadly occurrence [online]. *Sentinel Event Alert*. 2006 Apr 3 [cited 2009 Nov 4]. Available from Internet: http://www.jointcommission.org/SentinelEvents/SentinelEventAlert/sea_36.htm.
3. ECRI Institute. Fixing bad links: preventing misconnections in your hospital [guidance article]. *Health Devices* 2009 Jul;38(7):220-7.
4. International Organization for Standardization (ISO). Conical fittings with 6% (Luer) taper for syringes, needles and certain other medical equipment—part 2: lock fittings. ISO 594-2. 1998.
5. Guenter P, Hicks RW, Simmons D, et al. Enteral feeding misconnections: a consortium position statement. *Jt Comm J Qual Patient Saf* 2008 May;34(5):285-92,245.

(See Self-Assessment Questions on next page.)

Self-Assessment Questions

The following questions about this article may be useful for internal education and assessment. You may use the following examples or come up with your own.

1. Which of the following is NOT a tubing misconnection risk reduction strategy for clinical staff?
 - a. Trace all lines back to their point of origin after the patient's arrival to a new care area or as part of a handoff process.
 - b. Use standard Luer-connection syringes to administer oral medications.
 - c. Do not force connections.
 - d. Only use adapters that are clearly indicated for a specific application.
2. Which of the following is NOT a tubing misconnection risk reduction strategy for nonclinical staff?
 - a. Provide regular misconnection prevention education.
 - b. Develop a multidisciplinary team to assess the need for adapters throughout the facility, and limit or restrict routine use of adapters.
 - c. Train nonclinical staff on the proper technique for connecting or disconnecting devices or infusions.
 - d. Perform prepurchase evaluations and acceptance testing for safety and efficacy on tubing and catheters to assess the potential for misconnections.
3. Which of the following is NOT an enteral feeding tubing misconnection risk reduction strategy for clinical staff?
 - a. Use standard luer syringes for oral medications or enteral feeding.
 - b. Route lines with different purposes in unique and standardized directions (e.g., route intravenous [IV] lines toward the patient's head, route enteral feeding lines toward the patient's feet).
 - c. Prohibit modifying or adapting IV or enteral feeding devices.
 - d. Review identification labels before administering solutions to ensure that the intended delivery route is correct.
4. Which of the following is NOT an enteral feeding tubing misconnection risk reduction strategy for nonclinical staff?
 - a. Ensure that an adequate number of distinctly labeled enteral pumps are purchased to reduce or eliminate the use of infusion pumps for enteral administration to adult patients.
 - b. Ensure that syringe pumps for neonate feedings are clearly distinct from syringe pumps used for IV administration or other medical purposes.
 - c. Purchase only IV-compatible enteral feeding containers.
 - d. Secure enteral administration sets with enteral feeding containers before sending them to the patient care area.
5. A nurse inadvertently connects a patient's IV tubing to the nasal oxygen cannula upon the patient's arrival to the medical/surgical unit. Approximately five hours later, the patient complains of chest pain and shortness of breath. Select the *most appropriate* strategy to prevent this misconnection from occurring.
 - a. Trace all lines back to their point of origin after the patient's arrival to a new care area or as part of a handoff process.
 - b. Rely on color-coding to distinguish between various types of tubing.
 - c. Educate and train staff on an ongoing basis about preventing tubing misconnections.
 - d. Only use adapters that are clearly indicated for a specific application.
6. While changing a patient's gown, a family member inadvertently connected the patient's IV tubing to his gastric feeding tube. The misconnection was quickly noticed before the patient was seriously harmed. Select the *most appropriate* strategy to prevent this misconnection from occurring.
 - a. Rely on color-coding to distinguish between various types of tubing.
 - b. Educate about the need to request help rather than attempting to disconnect or reconnect lines.
 - c. Trace all lines from the patient back to their point of origin.
 - d. Perform prepurchase evaluations and acceptance testing for safety and efficacy on tubing and catheters, as appropriate, to assess the potential for misconnections.

PENNSYLVANIA PATIENT SAFETY ADVISORY

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