New Non-Luer Connectors
Rory Jaffe, MD MBA

Executive Director
CHPSO Patient Safety Organization
Member Small Bore Connectors ISO
work groups

Some illustrations provided courtesy of ASPEN: American Society for Parenteral and Enteral Nutrition, others from GEDSA: Global Enteral Device Supplier Association
CHPSO’s Role

- Member USA’s ISO work group
- Established multi-national group of clinical experts for neuraxial applications
- Active in ISO standards meetings
- Working with industry on roll-out and education plans
REASONS FOR AND SCOPE OF NEW CONNECTOR INITIATIVE
History of the problem

• Luer connectors were invented in the late 1890s to provide leak-free connections between glass hypodermic syringes and steel needles while allowing easy fitting and removal by pushing together and pulling apart (“Luer slip”). Several years later, a variant was made with threads so that the connectors would be screwed together and secured (“Luer lock”). Luer fittings became the standard for intravenous use, and then became popular for many other uses requiring small-bore connectors, from attaching blood pressure cuffs to inflation sources to connecting epidural catheters to anesthetic infusions.
History (cont.)

• With so many different applications using the same connector, accidental cross-connections, some fatal, began to appear.

• Soon there will be international standards for specialized connectors specific to neuraxial (e.g., epidural and intrathecal), blood pressure cuff, enteral and breathing / ventilator systems; each mechanically protected from connecting with the other. These connectors will also be protected from connecting with Luer fittings, which will continue to be used for intravascular and hypodermic applications.

• The risk of deadly cross connections will be significantly reduced by adopting physically incompatible connectors for different uses.
Breathing systems and driving gases
Enteral applications (not suction)
Limb cuff inflation
Neuraxial
Intravascular/Hypodermic
WHY AN INTERNATIONAL STANDARDS INITIATIVE?
Proprietary standards have been tried

- UK several years ago required non-compatible connectors for neuraxial use, but many problems arose
- Some styles of connectors caused usability issues during procedures
- Supply chain not standardized
  - Some hospitals received distal connectors without proximal mates and didn’t recognize the issue until a clinician could not successfully complete a procedure
  - Clinicians received surprises when new styles of connectors showed up
  - Patients transferred from one facility to another could face connection barriers if facilities using different proprietary connectors
More issues with proprietary connectors

• Not completely sure that the misconnection problem was addressed
  – Testing not standardized
  – Not crosschecked with other proprietary connectors
Scope of the international effort

Small bore connectors for liquids and gases in healthcare
- 80369-1: general requirements for small-bore connectors
- 80369-2: breathing systems and driving gases
- 80369-3: enteral
- 80369-4: urethral and urinary
- 80369-5: limb cuff inflation
- 80369-6: neuraxial
- 80369-7: intravascular or hypodermic
- 80369-20: common test methods

Small bore connectors for reservoir delivery systems
- 18250-1: general requirements
- 18250-2: breathing systems and driving gases
- 18250-3: enteral
- 18250-6: neuraxial (just started)
- 18250-7: intravascular
- 18250-8: citrate-based anticoagulant solution for apheresis
- 18250-9: irrigation
- 18250-20: common test methods

*Italic* = under consideration, not in progress
Two sets of standards (80369 and 18250)

18250: reservoir delivery

80369

80369

Today’s feeding systems
The ISO standards process is multinational

- 31 countries, each with one vote
- Each country submits extensive comments and text revisions
  - These are approved or not through consensus process
- Several rounds of review and voting before standard is published
- Process is slow, and some countries have different view of urgency than others
  - California deadline is major driver behind current ISO small bore connector standardization timeline
The ISO standards process is thorough

- Extensive materials, manufacturing and usability testing
- New connectors should be about as usable as prior, with some improvements
  - Fewer “Luer” leaks and glass syringe breakage—the Luer standard has been tightened
- Enteral connector with LDT modification does not decrease medication dosing accuracy
  - Tested
Color coding not in the standards

• Different manufacturers and different materials result in range of colors, even when standardized
• Color coding relies on memory and vision, not a forcing function
• Connectors and syringes might be color coded for convenience (e.g., purple for enteral), but this is not a standard requirement
Colors used for other, conflicting purposes
New designs to prevent cross-connections

**Enteral “ENFit™”**
- Reversed genders from IV
  - Prevents enteral line attachment to patient’s IV
- Male distal, female proximal
- ~ 20% larger than IV connectors
  - Prevents cross-connects

**Neuraxial “NRFit™”**
- About 20% smaller than IV connectors
  - Male IV connector too large for female neuraxial
- Collar on all male connectors, not just lock connectors
  - Male neuraxial collar interferes with larger female IV connector, prevents connection
Traditional male “Luer slip” vs. “Luer lock,” no collar vs. collar
Connector collar comparison

Male neuraxial slip with collar

Male neuraxial lock with collar
Neuraxial connector design

**Reservoir connector**
- Uses standard IV bag “spike”
- Does not prevent inadvertent use of IV tubing as an administration set

**Patient access**
- Prevents inadvertent connection of a neuraxial fluid line or neuraxial syringe to IV and vice-versa
Enteral connector design

**Reservoir connector**
- Prevents inadvertent use of IV tubing as an administration set

**Patient access**
- Prevents inadvertent connection of enteral administration set to IV tubing
Usability testing example: enteral

• Participants were a mix of caregivers that work in an ICU or NICU, and CNAs or people with a close friend, family member, or themselves that requires enteral feeding and medication administration at home

• These three user groups represent a variety of environments where enteral feeding and medication administration is provided. ICU, n=20; NICU, n=20; home, n=24

• Participants also represent a mix of ages and genders
Usability testing example: enteral (cont.)

• The objectives of the human factors study were to validate:
  – Caregivers do not attempt to connect male/female connector from the enteral connector system to other ports coming out of the manikin’s body.
  – Caregivers can successfully connect paired male/female enteral connector systems by twisting, or screwing, them into each other.
  – Caregivers can successfully administer enteral feeding or medication by having no leaks at the connection site due to participant error.
STATUS REPORT AND TIMELINES
NEURAXIAL STATUS
Neuraxial testing results

- Testing found that, under certain extreme circumstances, a male slip neuraxial connector could cross-connect to a female Luer connector with a big leak.
- There were many ways it could be redesigned—the committee chose the version that could be tested the fastest, in view of California’s deadline.
Neuraxial timeline post-testing

- Testing failure resulted in six-month design freeze timeline slip
  - Did not delay overall ISO process
- Did result in change in California timeline
  - Addressed later
ENTERAL STATUS
Primary Concerns Raised

• Low dose syringe accuracy
• Blenderized diet flow rate
• Other things could cross connect with small bore connectors
Low dose syringe accuracy
Dosing Accuracy Concerns

• Due to reverse gender from traditional Luer, there was concern that insertion of distal male connector into lumen of syringe tip would displace fluid and cause inaccuracies, particularly if there were inconsistent use of connectors

• No standard dosing accuracy requirement or specification for oral/enteral syringes

• Clinicians and pharmacists expected a dosing accuracy of ±10% of the target volume
  – With doses as small as 0.2mL delivered from a 1mL syringe

• Discovered that syringes 5 mL and below may require a low dose tip to satisfy accuracy target
Normal ENFit™ Tip Compared to Recently-Developed Low-Dose Tip
Examples Currently-Marketd Syringes
Enteral/Oral Syringe

Data above represent percentage of delivery accuracy with 95% confidence intervals. LSL and USL (designated with blue lines above) illustrate the 95% confidence interval. Target is ±10% of a 0.2mL dose delivered in a 1mL syringe.

<table>
<thead>
<tr>
<th></th>
<th>Lower CI</th>
<th>Upper CI</th>
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<tbody>
<tr>
<td>Cup Fill</td>
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<td>0.00</td>
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<tr>
<td></td>
<td>-9.26569</td>
<td>9.26569</td>
</tr>
<tr>
<td></td>
<td>Best Fit: Normal</td>
<td>Best Fit: Normal</td>
</tr>
</tbody>
</table>
Reverse Orientation Currently Marketed Syringe “F”

(F) Currently Marketed Reverse Orientation Syringe

<table>
<thead>
<tr>
<th></th>
<th>Cup Fill</th>
<th>Straw Fill</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower CI</td>
<td>-9.9060</td>
<td>-4.3549</td>
<td>-3.9630</td>
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<tr>
<td>Upper CI</td>
<td>28.6341</td>
<td>25.1744</td>
<td>21.2195</td>
</tr>
</tbody>
</table>

Best Fit: Normal  
Best Fit: Generalized Log.  
Best Fit: Johnson $S_l$
ENFit™ Syringes
Standard ENFit™

- Data above represent percentage of delivery accuracy with 95% confidence intervals.
- LSL and USL (designated with blue lines above) illustrate the 95% confidence interval.
- Target is ±10% of a 0.2mL dose delivered in a 1mL syringe.

**Cup Fill**

- Lower CI: -0.8346
- Upper CI: 34.3794
- Best Fit: Normal

**Straw Fill**

- Lower CI: -26.3193
- Upper CI: 19.7734
- Best Fit: Normal

**Overall**

- Lower CI: -24.0574
- Upper CI: 28.1478
- Best Fit: Normal
ENFit™ With Low-Dose Tip (LDT)

- Data above represent percentage of delivery accuracy with 95% confidence intervals.
- LSL and USL (designated with blue lines above) illustrate the 95% confidence interval.

**Cup Fill**
- Lower CI: -2.9091
- Upper CI: 11.4548
- Best Fit: Johnson Su

**Straw Fill**
- Lower CI: -4.06843
- Upper CI: 6.85843
- Best Fit: Normal

**Overall**
- Lower CI: -2.9027
- Upper CI: 10.4708
- Best Fit: Generalized Log
Conclusions

• Reverse orientation syringes
  – Significant dose inaccuracies at very low volumes (e.g., 0.2 ml)
  – Filling directly from cup worse than using straw

• Enteral/Oral syringe
  – Acceptable dose accuracy

• ENFit™ LDT
  – Acceptable dose accuracy cup or straw, slightly better with straw fill
Best Practices

• Removal of Residual Fluid
  – The LDT male lumen behaves similarly to the male nozzle on a standard male syringe.
  – LDT syringes, like standard syringes, should be tapped/flicked/wiped in order to remove fluid that may be outside the fluid pathway.

• Method of filling the syringe (cup fill vs straw/adapter fill)
  – The straw/adapter fill method is more accurate than the cup fill method because there is less potential for excess residual fluid on the syringe to transfer to the feeding tube.

• Orientation of the syringe and/or feeding tube during filling and disconnection
  – Depending on orientation during disconnection after filling, excess fluid may flow toward the syringe creating residual fluid on the syringe that can transfer to the feeding tube.
  – Depending on orientation during disconnection from the feeding tube after dispensing, excess fluid may flow into the feeding tube or fluid may flow back out of feeding tube.
Blenderized Diet Flow

• Will require testing once product in market
  – Controlled testing showed no problem, but…
  – Individual’s blending practices vary widely
  – Too many variations to rely solely on controlled testing

• May require customization for some patients
  – Change in blending practices, ingredients, or
  – Use of off-label or legacy devices
    • Legacy devices won’t leave worldwide market soon
    • Many patients already use off-label devices
Other things could cross connect with small bore connectors
A Matter of Trade-Offs

- Limited space to design
- Flexible plastic
- Many unstandardized items in the same general size range
  - For example, inside diameter of 15mm OD pediatric endotracheal tube adapters not standardized
- Many standardized items with standards maintained by other bodies
The World is Full of Things That Cross Connect
Protection Within 80369

• Clinically significant cross-connections within the series have been eliminated or made very difficult and very leaky by design

• Manufacturers now have defined procedure test cross-connections of novel/proprietary connectors with 80369 connectors
Delayed Deadline
• Delayed deadline for epidural connectors
  – From 1/1/2016 to 1/1/2017

• Delayed deadline for enteral connectors
  – From 1/1/2016 to 7/1/2016

• As with earlier delays, this third delay intended to allow orderly roll-out of ISO standard connectors
  – While legislation allows proprietary connectors that are already available, intent is to use ISO standard
What does California require?

• California law mandates using connector that will not fit into a connector other than the type it was intended for
  – Intravenous Jan 1 2016
  – Enteral feeding July 1 2016
  – Epidural Jan 1 2017
  – Applies to
    • General acute care hospitals
    • Acute psychiatric hospitals
    • Skilled nursing facilities
    • Special hospitals (dentistry or maternity)

• California law does not mandate:
  – Incompatible reservoir spikes

• Most cases seem to be errors at connector level, but still need caution
International connector standards’ status

• Breathing systems & driving gases restarting draft standard discussions
• Enteral final draft out to ballot
• Limb cuff inflation published
• Neuraxial being published
• Intravascular/hypodermic final draft out to ballot
US Standards

• In advance of international standards, to facilitate introduction
• Manufacturers could rely on US Standard to obtain accelerated FDA approval
• AAMI/CN3 Dec 2 2014 Enteral
• AAMI/CN6 Nov 16 2015 Neuraxial
PLAN FOR INTRODUCTION OF NEW CONNECTORS
Unexpected challenges

• Major USA/Canada manufacturer (BD) made announcements last week (enteral) and a month ago (neuraxial)
• Neuraxial syringes and spinal sets will not be available until mid 2018
• Declined to manufacture enteral products in reverse orientation, advises use of BD’s proprietary connectors and to wait for forward-oriented connectors BD will phase in within 5 years
AAMI/ISO CN3 on dose accuracy

• To date, risks associated with dose accuracy in medical devices designed with a reversed orientation have not been fully evaluated, and therefore, there is no proven need to explicitly exclude any subpopulations within the enteral clinical application. [We now know that several countries have been using reverse-oriented proprietary connectors without known issues, and the new low-dose design removes this issue.]

• A delay in progression of the standard for the introduction of a dedicated small-bore connector for a subpopulation can expose these patient groups to unacceptable risks from potential misconnections. It is therefore recommended that the [ENFit] Connector be used for all patients to reduce the risks of misconnection.

• Manufacturers incorporating the [ENFit] connector in medical devices intended for use with high risk subpopulations (e.g. neonatal patients) should evaluate any risk associated with this potential displacement and, if objective evidence indicates such a potential risk exists, should make the user aware of the potential for fluid displacement.
Enteral timeline (USA/Canada)

- Customers currently ordering sets with the stepped/Christmas tree connector receive transition feeding/administration sets compatible with both current feeding tube connections and new ENFit connector.
- 2016 Q2: Flush and bolus feed syringes
- 2016 Q2: Enteral feeding tubes
- Supply may be tight, particularly outside of California.
- Major USA syringe manufacturer (B-D) last week announced plans to phase in syringes in opposite orientation of other manufacturers over 5 years, urges use of its proprietary connectors in the meantime
Neuraxial timeline (USA/Canada)

• Second half 2016
• Unlike enteral connectors, expect proximal and distal connectors at same time
  – Lines tend not to stay in patient between care settings
  – Will not include transition connectors
• Primarily epidural and spinal products at first
  – Pressure transducers, peripheral nerve block products, etc. to follow
• B-D (which has large USA market share spinal, small share epidural) announced launch for spinal of Q2 2018, epidural Q3 2018
Why does it take so long?

• Requires new, expensive tooling
  – Most vendors reluctant to start “cutting steel” until standard frozen
  – Sampling, QA needed
  – Typically one year design to production

• For neuraxial connectors, complicated coordination of suppliers to produce parts for kits

• FDA streamlined process
  – No need for new 510k if only change is ISO connector
RISKS, NEW AND OLD, WITH THE TRANSITION AND NEW CONNECTORS
During changeover: Inconsistent adoption of ENFit™ connectors

- Some facilities may adopt the new devices before others
- If patient with new feeding tube is transferred to facility with old devices, that facility cannot use the tube
  - Thus the staged rollout, with transition adapters on administration sets tubes start being used
- If patient with an old device is transferred to facility with new devices, transition connector is needed
- Care delays unless recipient facility has proper connector or adapter

Recommendations:
- Assess connector types on transfer and on admission to anticipate and resolve connector challenges
- Ensure that facility is fully stocked with new feeding/administration sets (with transition connectors) and syringes before the new feeding tubes hit the market: In California ASAP! Rest of USA/Canada as supplies permit
- Do not start placing ENFit feeding tubes until a reliable supply of syringes secured – this may mean missing the July 1 2016 deadline
Proximal spike for neuraxial uses

• No change in proximal spike, so both neuraxial and intravenous administration sets can attach to neuraxial and intravenous solution reservoirs
• Supplying an intravenous administration set with a neuraxial solution will “force” intravenous administration unless caregiver double checks
• Accidentally mixing intravenous and neuraxial sets in a bin could lead to wrong route errors
• Recommendations:
  – Manufacturers plan to prominently distinguish connectors on the label
  – Pharmacy can package neuraxial fluid reservoirs with neuraxial sets (e.g., rubber band together)
  – Consider whether stocking neuraxial sets on wards is wise or not (e.g., risk of mix-ups in bins)
• New work item proposal just submitted to ISO for spike replacement
Mis-filled syringes or fluid reservoirs

• Remain an issue, currently appears to happen much less frequently than misconnections of properly filled containers
• Nurses still need to be aware of correct route for each medication, and systems (e.g., CPOE) should continue to check for proper route
• The new connectors are a component of “defense in depth” for potentially disastrous events, not a substitute for current defenses
Cross-connections with male slip

- Limited “space” to design interferences between all the small-bore connectors.
- Lack of threads in slip connector (and collar in Luer slip) removes some potential interferences.
- Cross-connections that do occur appear to be low risk.
  - Primarily interruption of IV therapy, not injection of harmful substances into wrong route.
- Recommend minimizing use and storage of Luer slip devices.
PHARMACY CHALLENGES
Inconvenience increases

• Of necessity, introducing non-interchangability increases inconvenience—will need two new types of connectors
  – And will need to take steps to prevent confusion between the connectors, particularly when order is ambiguous
• May pose a challenge if med orders haven’t specified oral vs. enteral
  – Might end up placing all in ENFit syringes or make orders more specific
• Some neuraxial devices will be Luer for a while longer (e.g., Ommaya reservoir)
  – Don’t know when Huber needle assemblies will have NRFit option, so may need to use NRFit for some neuraxial injections, Luer for others
HOSPITAL MATERIAL MANAGEMENT CHALLENGES
Purchasers’ influence

- Deadlines strictly applies only to California
- USA probably will proceed at same pace unless supply is tight
  - Supply may be tight, particularly for enteral syringes
- To ensure compliance with the law, hospitals should identify, as soon as possible, suppliers that should meet the deadline
  - Create market demand in advance of changeover, incentivize suppliers that move quickly to meet California legal requirements
  - GPOs have prominent role in USA supply chain and should be partner in this effort
  - This may mean delaying adoption (by several months) in other states
  - This also may mean that GPOs and hospitals will need to switch suppliers if the traditional suppliers might fail to meet the required deadline
Material management changes

• More SKUs
  – Syringes in at least three fitting types, multiple types for needles, etc.
  – Infusion pump tubing in multiple types
  – Connectors, other tubing, etc.
• Need to identify where neuraxial and enteral uses occur
  – In past, didn’t necessarily need different types of fittings on the wards, now will
• Stock “transition connectors” during the transition period
  – Enables cross fit conic-ended enteral tubes to new fitting
• Recommend facility-wide rollout rather than ward by ward
  – Supply chain will be rapidly emptied of old-style connectors for use-specific devices (e.g., spinal needles, feeding tubes)
  – Differently phased rollouts will confuse and frustrate clinicians who work in multiple locations
  – Will roll out proximal and distal sets separately for enteral uses, using bridge connectors in the transition
  – Neuraxial devices tend to stay in patients for less time, roll out proximal and distal sets simultaneously
Potential material management surprises: Neuraxial

• Intravenous/hypodermic supplies may currently be used for neuraxial uses without the knowledge of materials management
  – Major nerve blocks, while not technically “neuraxial”, will be included
  – Common needles (e.g., 22g long) may be needed in both Luer and neuraxial fittings
  – IV catheters may also be used for major nerve blocks
• May be asked to supply neuraxial connectors for chemical nerve ablation use, such as in a pain clinic
• Pharmacy, clinician-users, and materials management need to coordinate plans
Other potential neuraxial material management surprises

• Spinal needles may be used for non-neuraxial purposes
  – E.g., amniocentesis, joint space aspiration
  – These uses will also need to be converted to the new connectors or to purpose-built needles

• California law only requires the new connector for epidural uses
  – Some manufacturers, strapped for time, may delay production of the new spinal needles
  – Pharmacy should distinguish Ommaya reservoir from other intrathecal routes, as may need Luer for Huber needle until suppliers provide Huber needle with NRFit hub

• Inventory neuraxial uses and supply needs
  – At a minimum, survey oncologists, anesthesiologists, pain specialists, interventional radiologists, and ED physicians
Potential material management surprises: enteral

• Medication administration may be carried out in different ways
  – Work with pharmacy to identify medication uses
  – Pharmacy should differentiate between oral and enteral orders

• Many of the enteral lines the hospital deals with were introduced into the patient elsewhere
  – Patients will come in to hospital with a variety of connector types for their indwelling enteral lines
  – Work with GI, nursing, to identify current connector use, current workarounds for odd connectors, etc., then find ways to address these issues with the new connector sets
  – Patients changing feeding tubes at home may use cut-off Foley catheters to save money, and thus may still have conic connectors even after new feeding tubes are on the market
Other recommendations

• Prepare by assessing systems processes and protocols that may need to change
• Work with suppliers to coordinate transition plans
• Plan to train clinicians and materials management staff for impending changes
• Be aware that several neuraxial uses may require specialized equipment
  – Blood patch (one-way adapters have been used in UK)
  – Caudal anesthesia
Stay tuned for more

- Contact Rory Jaffe ([rjaffe@chpso.org](mailto:rjaffe@chpso.org)) with any questions
- [http://stayconnected.org/](http://stayconnected.org/)
Questions