Implanted Drug Administration Pump and Catheter for Intrathecal Delivery

Michael Schabacker, M.D.
Medications for spinal anesthesia have been administered intrathecally for years.

- In the 1980s continuous administration of morphine and baclofen to address spasticity from cerebral palsy and spinal cord injury was studied.
- Drug administration pumps for implantation were developed to continuously administer medications.
- These pumps were developed using both hydraulically driven and computer programmed electronic devices using a rotor.
- There are several manufacturers of implanted drug administration pumps.
- Drug administration pump developed by Medtronic Corporation have been exclusively used in our clinic.
Several Infusion Systems Available for Targeted Drug Delivery

MEDSTREAM™ Programmable Infusion Pump and Control Unit

Prometra Pump and Programmer

SynchroMed II Infusion Pump & N’vision Clinical Programmer

Medtronic
Advantages of Intrathecal Drug Administration.

• Avoids 1\textsuperscript{st} pass effect.
• Eliminates the need for drug to cross the blood brain barrier.
• By direct access to the receptors, equal analgesic dose of intrathecally delivered medication is markedly lower than other means of medication administration.
• May obviate the need for transdermal or oral medications.
• Less risk for misuse or abuse of intrathecally administered medications.
Anatomy of the Thecal Sac

- The *thecal sac* or *dural sac* is the membranous sheath of dura mater that surrounds the spinal cord and the cauda equina. The *thecal sac* contains the cerebrospinal fluid in which the spinal cord 'floats'. Medication administered into the thecal sac is distributed by the cerebral spinal fluid that bathes the spinal cord and nerve roots.
Anatomy of the Lumbosacral Spine

- Spinal cord
- Skin
- Subcutaneous tissue
- Interspinous ligament
- Supraspinous ligament
- Ligamentum flavum
- Epidural space
- Intrathecal space
- Cerebrospinal fluid
- Epidural spinal needle
- L1, L2, L3, L4, L5
- S1
- Intervertebral disc
- Vertebral body
- Dura and arachnoid layers
- Cauda equina (spinal nerves)
- Area shown

Cut-away view of spine.
A. Surgical set-up

B. Insert needle at L3-L4 interspace

C. Thread in catheter
K: Suture catheter with plastic anchor and sutures
L: Create pocket for pump
M: Extend tunneling device through subcutaneous tissues and then tunnel catheter through device
N: Coil catheter into pocket, place pump inside, and suture closed
Implanted drug administration pump maintenance.

• Implanted drug administration pump best be refilled before reservoir volume drops below 2 mL.
• Pump performance diminishes after reservoir volume drops below 2 mL.
• Specialized training is required for pump maintenance.
• Prior to pump refill, the pump is interrogated using a telemetry device.
• Side access port is used for orientation when placing a template over the pump to direct needle placement when accessing reservoir.
• The pump reservoir is then accessed with a Huber needle and all remaining medication is removed and discarded.
• Microfilter is used when filling the pump with preservative-free medication.
Implanted drug administration pump maintenance.

- Pump is then updated reflecting the volume of medication placed in the reservoir and change in medication delivery rate if indicated.
- Medication is typically delivered at a continuous rate.
- It is possible to vary the rate of medication delivery over the course of each day to accommodate for times when additional analgesia is needed.
- Pump can be programmed to allow the patient to deliver small boluses of medication as needed using a hand-held telemetry device. Parameters are set at the time of pump programming.
- Special consideration is required when new medication is placed in the pump or when a concentration change is made. Because the medication cannot be removed from the internal tubing of the pump and the catheter, pump dynamics must change at the time the new medication reaches the catheter tip. This is called a bridge bolus.
Patient Selection for Intrathecal Drug Therapy.

• Cancer related pain in patients with at least 3 month life expectancy.
• Failed back syndrome, which is the most common diagnosis for which intrathecal drug therapy is provided.
• Spasticity related to spinal cord injury is responsive to baclofen and to the combination of baclofen and morphine.
• Peripheral neuropathy, interstitial cystitis, postherpetic neuralgia, postmastectomy syndrome and systemic diseases such as rheumatoid arthritis have been mentioned in the medical literature as viable conditions for intrathecal drug treatment.
• Disease state is only one component to consider selecting patients for possible intrathecal drug therapy.
Session Data Report
8840 Synchromed II B Programming Session

Patient Information
First Name
Last Name

Pump Serial Number
EDDSC080210
Pump Model Number
SX37-40 40 mL
Cal. Constant
116

Catheter Information
Catheter Model
8731
Pump Segment
Volume per cm
0.0023 mL/cm
Length
66.0 cm
Removed
5.0 cm
Implanted
61.0 cm

Spinal Segment
Volume per cm
0.0022 mL/cm
Length
38.1 cm
Removed
5.0 cm
Implanted
33.1 cm

Total Catheter Volume
0.229 mL

Current Pump Settings
Examined At
06/14/2017 MM/DD/YYYY 14:56
Last Change
06/14/2017 MM/DD/YYYY 16:24

Infusion Drug
Drug
1 PENTANYL
3.000.0 mcg/mL

Infusion Mode
Simple Continuous

Dose Per Day
1 PENTANYL
893.8 mcg/day

Estimated TRL
73 Months

Reservoir Volume
4.9 mL
Low Reservoir Alarm Volume
2.0 mL
Refill Interval
5 days
Low Reservoir Alarm Date
06/23/2017 MM/DD/YYYY

Critical Alarm Interval
01:00 h:m
Non-Critical Alarm Interval
01:00 h:m

Pump Status After Update
Last Change
06/14/2017 MM/DD/YYYY 14:57
Infusion Drug
Drug
Concentration
1 PENTANYL
3.000.0 mcg/mL

Infusion Mode
Simple Continuous

Dose Per Day
1 PENTANYL
893.8 mcg/day

Estimated TRL
73 Months

Reservoir Volume
40.0 mL
Low Reservoir Alarm Volume
2.0 mL
Refill Interval
127 days
Low Reservoir Date
10/15/2017 MM/DD/YYYY

Critical Alarm Interval
01:00 h:m
Non-Critical Alarm Interval
01:00 h:m

AnasaziHealth @ P74656805600

 medicare Hosp. No. 0001
 P.O. Box 5070
 Twin Falls, ID 83301

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Session Data Report
8840 SynchroMed II B
Programming Session

Patient Information
First Name
Last Name
Birth Date

Pump Serial Number
B9V798222H
Pump Model Number
6437-40 40 mL
Cml. Constant
125

Catheter Information
Catheter Model
8780
Pump Segment
Volume per cm
0.0032 mL/cm
Length
27.9 cm
Removed
0.0 cm
Implanted
27.9 cm
Spinal Segment
Volume per cm
0.0022 mL/cm
Length
86.4 cm
Removed
22.5 cm
Implanted
63.9 cm
Total Catheter Volume
0.202 mL

Current Pump Settings
Examined At
05/26/2017 NE/DX/DYDDT 15:40
Last Change
07/12/2017 NE/DX/DYDDT 16:13

Infusion Drug
Drug
Concentration
1 MORPHINE
30.0 mg/mL
2 BUPIVACAIN
8.0 mg/mL
3 HYDROCORTISON
0.2 mg/mL

Infusion Mode
Simple Continuous
Drug
Dose Per Day

Infusion PA
Drug
PA Dose
Total Maximum Daily Dose
Increase in Daily Dose
1 MORPHINE
0.500 mg
3.742 mg/day
2 BUPIVACAIN
0.2000 mg
1.8868 mg/day
3 HYDROCORTISON
0.06900 mg
0.08743 mg/day

PA Duration
00:10 h:mm
PA Lockout Interval
01:00 h:mm
Dose Restriction Interval
24 / 24:00 h:mm
Maximum Activations/Day
1
Display Time Remaining
Disabled
Diary
Disabled
Activation History
Successfully Activated
166
Lockout Attempts
0
Unsuccessful Activations
2

Estimated SRI
36 Months

Reservoir Volume
7.4 mL
Low Reservoir Alarm Volume
1.0 mL
Refill Interval
13 days
Refill Date at Max Activations
10/09/2017 NE/DX/DYDDT

Critical Alarm Interval
00:10 h:mm
Non-Critical Alarm Interval
01:00 h:mm
### Pump Status After Update

**Last Change:** 09/26/2017 3/20/2017 13:55

#### Infusion Drug

<table>
<thead>
<tr>
<th>Drug</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>MORPHINE</td>
<td>20.0 mg/mL</td>
</tr>
<tr>
<td>KETORACAIN</td>
<td>8.0 mg/mL</td>
</tr>
<tr>
<td>RACLOPEN</td>
<td>0.2 mg/mL</td>
</tr>
</tbody>
</table>

#### Infusion Mode

- **Daily Dose Change:** 0%
- **Simple Continuous Drug**
- **Dose Per Day:**
<table>
<thead>
<tr>
<th>Drug</th>
<th>Amount/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>MORPHINE</td>
<td>7.52 mg/day</td>
</tr>
<tr>
<td>KETORACAIN</td>
<td>3.0 mg/day</td>
</tr>
<tr>
<td>RACLOPEN</td>
<td>0.075 mg/day</td>
</tr>
</tbody>
</table>

#### Infusion PA

- **PA Dose:**
  - **Total Maximum Daily Dose:**
    - **MORPHINE:** 9.742 mg/day
    - **KETORACAIN:** 3.8568 mg/day
    - **RACLOPEN:** 0.09742 mg/day
  - **Increase in Daily Dose:**
    - **MORPHINE:**
      - 9.742 mg/day
    - **KETORACAIN:**
      - 3.8568 mg/day
    - **RACLOPEN:**
      - 0.09742 mg/day
  - **PA Duration:** 00:10 h:m
  - **PA Lockout Interval:** 01:00 h:m
  - **Dose Limitation Interval:** 24:00 h:m
  - **Display Time Remaining:**
    - **Enabled:**
      - **Diary:**
        - **Disabled:**
          - **Activation History:**
            - **Successful Activations:** 0
            - **Lockout Attempts:** 0
            - **Unsuccessful Activations:** 0

### Estimated ERI

- **30 Months**

#### Reservoir Volume

- **40.0 mL**
  - **Low Reservoir Alarm Volume:** 1.0 mL
  - **Refill Interval:** 90 days
  - **Refill Date at Max Activations:** 12/15/2017

#### Critical Alarm Interval

- **00:10 h:m**

#### Non-Critical Alarm Interval

- **00:09 h:m**
Psychological assessment is mandatory prior to considering intrathecal drug therapy in nonmalignant pain

• Medicare requires psychological evaluation prior to implantation.
• In our clinic, all patients must complete a psychological assessment prior to evaluation by Dr. Goodman.
• Psychological assessment is meant to achieve several objectives including assessment of the patient’s expectation of the therapy and to ensure there are no underlying psychiatric conditions that would complicate pump management.
• Once the pump is placed, the patient is forever bound to our practice for maintenance of the device and as such, the psychological assessment provides us with helpful insight.
Questions to consider before intrathecal pump placement.

• Are the pain complaints related to an objective physiologic diagnosis?
• Have less invasive therapies been tried or considered?
• Is the patient’s life expectancy 3 months or longer?
• Is the patient’s function limited by the pain symptoms?
• Is the patient psychologically stable?
• Is there uncontrolled psychosis, severe depression, intractable anxiety or significant personality disorders?
• Is the patient compliant with other treatment recommendations?
Questions to consider before intrathecal pump placement.

• Does the patient have any contraindications to pump placement such as bacteremia, bleeding disorder or localized infection?
• Has an acceptable trial been performed to document adequate pain response and controllable side effects?
• Is the patient aware of the expectations of the procedure?
• Is the patient agreeable to permanent pump placement despite the risks of the procedure and long-term risks of the drugs to be infused?
• Does the patient accept and acknowledge the risks associated with implanted drug administration pump and those associated with routine maintenance of the device?
Intrathecal drug trial prior to implantation.

• If patient is deemed to be appropriate for intrathecal medications and has satisfactorily completed a psychological assessment, then intrathecal drug trial is required prior to implantation of the catheter and pump.

• Previously, candidates for intrathecal therapy were admitted to the hospital for placement of a temporary intrathecal catheter and several days of medication infusion.

• Medicare and other insurance will no longer pay for in-hospital drug trial. The trial has transitioned to a single shot of medication placed in the cerebral spinal fluid in the mid lumbar area.

• Goal of the trial is to demonstrate tolerance of the drug and at least some report of pain relief.

• Invariably, if a patient tolerates the medication and appreciates some modicum of pain relief, better analgesia can be achieved once the pump is implanted.

Neuromodulation 2012; 15: 436–466
2012 Polyanalgesic Algorithm for Intrathecal (IT) Therapies in Neuropathic Pain.

Line 1 Morphine, Ziconotide, Morphine + bupivacaine
Line 2 Hydromorphone, Hydromorphone + bupivacaine or Hydromorphone + clonidine, Morphine + clonidine
Line 3 Clonidine, Ziconotide + opioid Fentanyl, Fentanyl + bupivacaine or Fentanyl + clonidine
Line 4 Opioid + clonidine + bupivacaine, Bupivacaine + clonidine
Line 5 Baclofen

2012 Polyanalgesic Algorithm for Intrathecal (IT) Therapies in Nociceptive Pain.

Line 1 Morphine Hydromorphone, Ziconotide, Fentanyl
Line 2 Morphine + bupivacaine, Ziconotide + opioid, Hydromorphone + bupivacaine, Fentanyl + bupivacaine
Line 3 Opioid (morphine, hydromorphone, or fentanyl) + clonidine, Sufentanil
Line 4 Opioid + clonidine + bupivacaine, Sufentanil + bupivacaine or clonidine
Line 5 Sufentanil + bupivacaine + clonidine
Recommended Starting Dosage Ranges of Intrathecal Medications.

Morphine 0.1–0.5 mg/day  
Hydromorphone 0.02–0.5 mg/day  
Ziconotide 0.5–2.4 mcg/day  
Fentanyl 25–75 mcg/day  
Bupivacaine 1–4 mg/day  
Clonidine 40–100 mcg/day  
Sufentanil 10–20 mcg/day
Concentrations and Doses of Intrathecal Agents by the Polyanalgesic

<table>
<thead>
<tr>
<th>Drug</th>
<th>Maximum concentration</th>
<th>Maximum dose per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine</td>
<td>20 mg/mL</td>
<td>15 mg</td>
</tr>
<tr>
<td>Hydromorphone</td>
<td>15 mg/mL</td>
<td>10 mg</td>
</tr>
<tr>
<td>Fentanyl</td>
<td>10 mg/mL</td>
<td>No known upper limit</td>
</tr>
<tr>
<td>Bupivacaine</td>
<td>30 mg/mL</td>
<td>10 mg</td>
</tr>
<tr>
<td>Clonidine</td>
<td>1000 mcg/mL</td>
<td>40–600 mcg/day</td>
</tr>
<tr>
<td>Ziconotide</td>
<td>100 mcg/mL</td>
<td>19.2 mcg/day</td>
</tr>
</tbody>
</table>
Potential complications of implanted drug administration pump for intrathecal delivery.

- Pump pocket fill.
- Needle either is not in the pump reservoir at the time medication is administered for the needle unknowingly is removed from the reservoir during the refill process.
- Safeguards to detect inappropriate needle placement include clarity of fluid removed from pump reservoir, monitoring volume aspirated from the pump, and comparing that to expected volume.
- Periodic barbotage during refill process to ensure that medication is easily withdrawn from the reservoir and that aspirated fluid remains clear.
Potential complications of implanted drug administration pump for intrathecal delivery.

• Pump pocket fill can be result in massive opiate overdose.
• Fentanyl would seem potentially to pose the greatest risk given the high concentration of fentanyl frequently used.
• Pump pocket fill with a large volume of bupivacaine would most likely be an unrecoverable complication.
• Monitoring for at least 30 minutes post refill was implemented in our clinic quite some time ago to ensure that in the event pump pocket fill occurred, the complication would be detected before leaving clinic.
Potential complications of implanted drug administration pump for intrathecal delivery.

- Abrupt cessation of pump function is associated with acute withdrawal.
- Abrupt cessation of pump function occurs with pump failure (device is mechanical and subject to failure), catheter migration (medication delivered outside the thecal sac has very little effect), catheter kink, catheter dislocation from the pump, pump not filled on time with exhaustion of medication supply and other potential causes.
- Acute withdrawal of intrathecal baclofen in patients treated for spasticity can have dire consequences including rhabdomyolysis, kidney failure and even death.
- Acute withdrawal from opiates and other medications typically used in the pump can be managed with administration of opiates parenterally or orally.
Potential complications of implanted drug administration pump for intrathecal delivery.

• Iatrogenic drug overdose is at all times of concern.
• The most likely cause of drug overdose is misprogramming and as such, in our clinic, pump adjustments are double checked by another provider prior to patient leaving clinic.
• Errors in medication formulation from the compounding pharmacy could have dire consequences including drug overdose. From time of pump refill, it takes hours to days for the medication newly placed in the pump reservoir to reach the end of the catheter. Misformulation of the medication will not manifest until medication reaches the catheter tip.
• Drug overdose due to malfunction of the pump is possible, although very rare.
Potential complications of implanted drug administration pump for intrathecal delivery.

• Other potential causes of iatrogenic drug overdose can develop at time of modification of the pump or catheter.

• Of particular concern is at time of pump replacement or revision of the catheter. If the pump and/or catheter had not been functioning correctly, and revision is undertaken without consideration of the fact the patient is no longer tolerant to the medication, overdose is possible.

• Failure to accommodate change in concentration at time of refill or placement of a new medication can result in drug overdose or underdose once the medication reaches the catheter tip.
Potential complications of implanted drug administration pump for intrathecal delivery.

• Peripheral edema is a relatively common with intrathecally delivered opiate medications.

• Discontinuation of the offending medication typically results in abrupt resolution of the peripheral edema.

• Many patients do not develop peripheral edema on an alternative opiate. Peripheral edema that develops to an opiate delivered intrathecally is not necessarily a contraindication to intrathecal opiate delivery.
Potential complications of implanted drug administration pump for intrathecal delivery.

- Granuloma formation can occur at catheter tip.
- Certain intrathecally delivered medications have greater propensity for granuloma formation with hydromorphone perhaps being the most onerous followed by morphine.
- Granuloma at catheter tip can have dire consequences if left unaddressed including paraplegia.
- Manifestation of granuloma may be new pain in the lower thoracic and abdominal wall as granuloma applies pressure to nerve roots at the location of the granuloma.
- Granuloma will block egress of medication resulting in gradual decline in quality of analgesia that is unresponsive to dose increase of intrathecally delivered medication.
- Granuloma may be associated with progressive numbness and weakness in the lower extremities, development of neurogenic bowel and bladder and paraplegia.
- Long tract signs such as positive Babinski and hyperreflexia may be signs of evolving myelopathy secondary to granuloma.
- High level of suspicion is at all times required.
Consideration of intrathecally delivered medications.

• There is a reasonable body of medical literature that demonstrates efficacy of implanted drug administration pumps for intrathecal delivery.

• As declining acceptance of oral and transdermal opiate management of chronic pain evolves, likely there will be greater reliance on implanted drug administration pumps.

• There is a fair amount of risk associated with the use of implanted drug administration pumps for intrathecal delivery that must be considered prior to implementation of this treatment and throughout the course of treatment.
Consideration of intrathecally delivered medications.

- Patients on stable doses of intrathecally delivered medication do not typically spontaneously develop obtundation and respiratory depression.

- Given the general lack of familiarity with this technology, it is common to attribute changes in the patient’s health to the drug administration pump. At all times, diligence in looking beyond the pump is necessary as often, the pump is not responsible for the changes in the patient’s health.

- If questions or concerns arise relative to a drug administration pump managed through my clinic, we are happy at all times to address those questions.

- Medtronic technical support is an invaluable resource for information relative to the drug administration pump. Medtronic technical support contact information is readily available online.