Interventional Pain Management Reports
ISSN 2575-9841 Volume 2, Number 6, pp 227-234

Case Report

Inadvertent Spinal Shock during an Intrathecal Drug Delivery System Refill – A Case Report and Troubleshooting Algorithm

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Intrathecal drug delivery systems (IDDS) are used to treat patients with chronic refractory pain syndromes and spasticity. IDDS offer an effective therapy to control pain while offering the advantage of a decrease in the incidence of side effects from high-dose systemic opioid therapy. Serious outcomes including death or permanent brain damage may occur from medication administration errors, primarily during maintenance of IDDS. The pump refill and reprogramming procedures, although elemental in theory, are not bereft of serious and fatal side effects .The importance of understanding the IDDS and competency in performing pump refills and programming is of critical importance. To reduce the risk of drug-related errors, particular attention should be paid to the proper functioning of pump hardware, drug reservoir volume discrepancies and overdose symptoms reported by patients. Furthermore, the clinician should be prepared for drug errors and follow the risk mitigation flowchart mentioned in the clinician refill reference card provided by the IDDS manufacturer. We present a case report of a 62-year old male with a history of post-laminectomy syndrome, associated with chronic back pain for the last 4 years. The patient developed inadvertent total spinal shock during a refill procedure of the IDDS reservoir. The educational objective of this case report is to highlight troubleshooting options, plus some of the risks and complications that can occur when managing an intrathecal pump delivery system. Clinicians involved in the ongoing care of patients with IDDS should undergo periodic competency validations. Imaging modalities are useful adjuncts for intrathecal pump refills when a patient has a more difficult entry or previous complications at the time of refill. A rapid recognition of evolving complications and implementation of appropriate treatment are the cornerstones of successfully managing complications associated with refilling of IDDS.

Key words: Intrathecal drug delivery system, drug refill, total spinal shock, seroma, catheter port study, rotor study

Intrathecal drug delivery systems (IDDS), approved by Food and Drug Administration in 1991, are used to treat patients with chronic refractory pain syndromes and spasticity (1). More than 300,000 intrathecal pumps have been implanted for chronic refractory pain since the first use of an implantable IDDS pump for intractable cancer pain in 1981 (2,3). An IDDS is a highly complex system, essentially composed of a subcutaneous pump that stores medications in a refillable reservoir and delivers them into the intrathecal space via a catheter. A variety of medication including neuropathic agents, opioids, and local anesthetics can be delivered through the IDDS (4). Furthermore, this system allows for a minimal dosage of opioids to be deposited precisely at the level of dorsal horn cells, which is proposed to be the site for modulation of afferent information through a variety of complex mechanisms. IDDS offer an effective therapy to control pain while offering the advantage of a decrease in the incidence of side effects from high-dose systemic opioid therapy (5). Depending on the dose regimen,

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drug concentration, use of a Patient Therapy Manager (PTM), the pump reservoir needs to be refilled with the appropriate volume and concentration of the drug every typically every 30-90 days (6). The pump refill and reprogramming procedures, although elemental in theory, are not bereft of serious and fatal side effects (7). The educational objective of this case report is to highlight troubleshooting options, plus some of the risks and complications that can occur when managing an intrathecal pump delivery system.

Clinical Vignette

We present a case report of a 62-year old male with a history of the post-laminectomy syndrome, associated with chronic back pain for the last 4 years. The patient has been on an uncomplicated clinical course with SynchroMed IIb intrathecal pump (Medtronic, Minneapolis, MN) delivering hydromorphone and bupivacaine therapy for approximately the last 4 years. The patient returned to our pain clinic for a routine refill of the intrathecal pump reservoir. The IDDS interrogation revealed reservoir volume of 20 mL and pump volume of 40 mL. The medication solution consisted of hydromorphone 0.5mg/mL and bupivacaine 30 mg/mL, which was same as the previous medication solution in the IDDS. Using standard, sterile precautions, the physician was able to aspirate 23 mL of clear medication solution from the reservoir of the pump. Subsequently, using an air filter, new medication solution was prepared for injection (40 mL) into the reservoir port of the IDDS. Following the standard practices of our pain clinic on injection of the new medication into the reservoir, the physician aspirated 1 mL of medication back for every 5 mL of medication injected in the reservoir. The authors employ this technique to ensure that the needle used to refill the medication is within the access port and the drug solution is being deposited in the reservoir. The pump was reprogrammed and the rate was set at 0.10688 mg/day of hydromorphone (same as before). Approximately 5 minutes after the refill procedure, the patient complained of weakness in the legs and numbness in the abdomen. In the next few minutes, the patient became increasingly nauseous and reported numbness in the hands and feet, tingling sensation in the lips and his arms and legs became heavy and atonic. There was concern that inappropriate deposition of medication had occurred elsewhere other than in the reservoir. The emergency response team was immediately notified, with concerns for inadvertent intrathecal deposition of medication. The sensory level was at T1 and the patient started developing waxing and waning consciousness along with hypotension and sinus bradycardia (blood pressure - 75/30 mm Hg and HR - 38 beats/min). At that point, 10 mg boluses of ephedrine up to a total of 40 mg via intravenous route, was administered immediately and the patient was intubated by the senior staff pain physician in the pain clinic with 16 mg of etomidate and 100 mg of Rocuronium administered before intubation. An 18-gauge intravenous catheter was then placed, all under aseptic precautions, in the right internal jugular vein and a norepinephrine infusion was initiated and titrated to maintain the blood pressure and heart rate within normal limits. The vitals gradually stabilized to normal limits with the aid of a norepinephrine infusion and the patient was transferred to an interventional radiology suite emergently, where 47 mL of cerebrospinal fluid (CSF) was aspirated. The patient's clinical condition did not change after removing the cerebrospinal fluid and he was transferred to the intensive care unit for invasive ventilation, monitoring, and supportive therapy (Fig. 1). The computerized tomography images of the spine reported intact intrathecal catheter (Fig. 2). In the next 24 hours, the neurological status of the patient came back to baseline and he was extubated uneventfully in the intensive care unit. The senior pain physician explained in detail his thoughts on the series of events which led to the inadvertent spinal deposition of the drug. The patient and family understood the issue and agreed to have the IDDS interrogated further. The patient was then transported to a fluoroscopy room for evaluation of his intrathecal pump. The side port study and pump rotor interrogation report did not reveal any gross mechanical issues with the intrathecal catheter or with the pump mechanics (Fig. 3). The ultrasound exam of the IDDS, done in the fluoroscopy suite, revealed a seroma near the pump site. The seroma fluid was aspirated and tested positive for CSF. Furthermore, the 18 mL of medication was aspirated from the pump instead of 40 mL, suggesting that the pump reservoir had never been entered the day before. It was then proposed that the seroma pocket might be the possible location where the medication was deposited and it was also postulated that the medication spread along the catheter tract into the intrathecal space leading to a sudden and severe

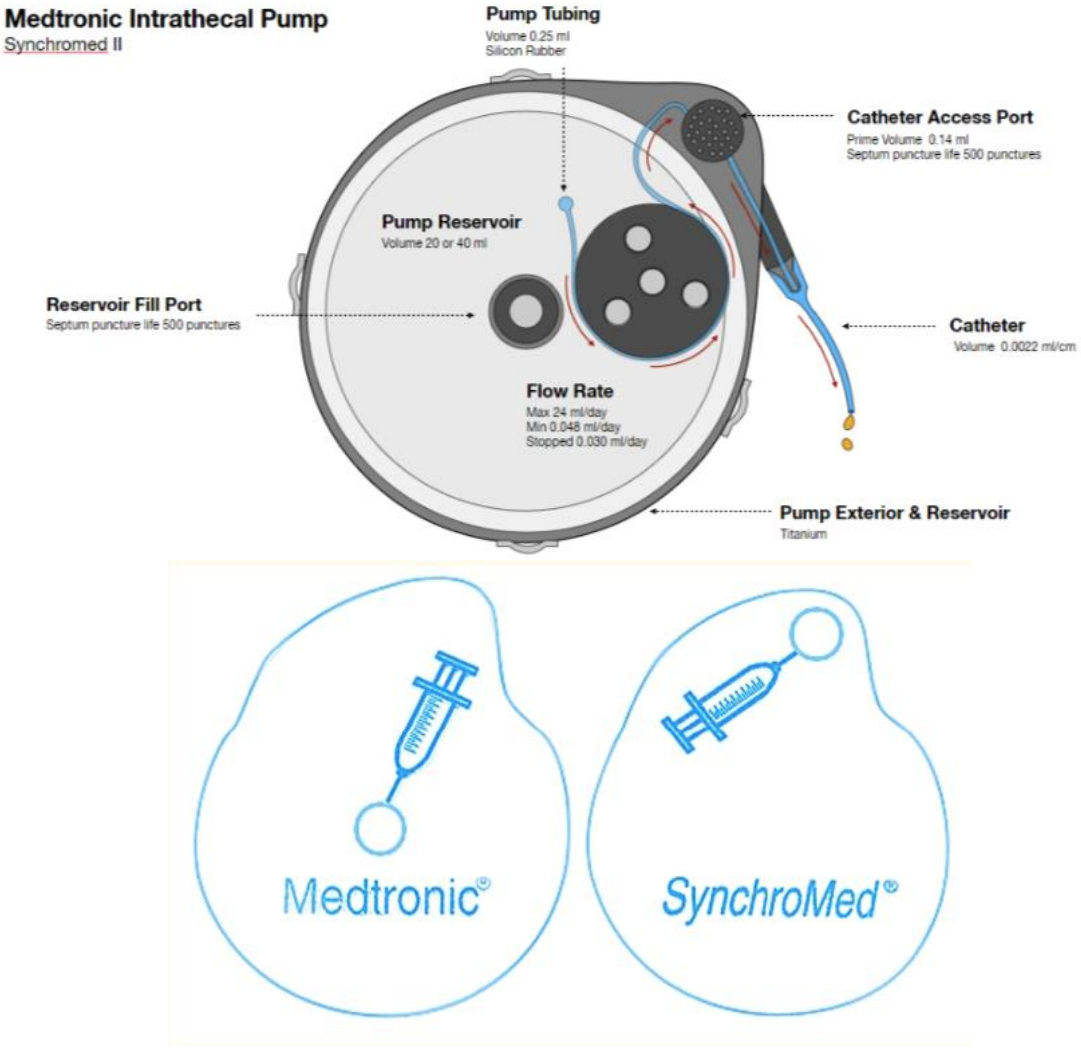

Fig. 1. SynchroMed II Pump: Pump components (above) and SynchroMed templates. Clear plastic overlays are placed over the palpated pump to help locate the correct port. Left, the refill kit template allows only reservoir access. Right, the catheter access kit template allows only catheter access. Accidental use of this template during refilling of the pump has led to fatalities.

onset of symptoms. An ultrasound was used this time to identify the reservoir port site. The medication was aspirated from the port and tested for CSF using glucose and protein reagent strips. Once the test was negative for CSF, the appropriate volume of intrathecal drug solution was deposited uneventfully in the reservoir port. The patient was discharged home and at 1-week follow up he didn't report any residual neurological sequelae that could be attributed to the iatrogenic high spinal sympathetic block.

DISCUSSION

A review of closed claims data due to implantable devices for chronic pain since 1990 reported that 64% (94/148) of the claims are due to IDDS. Out of these

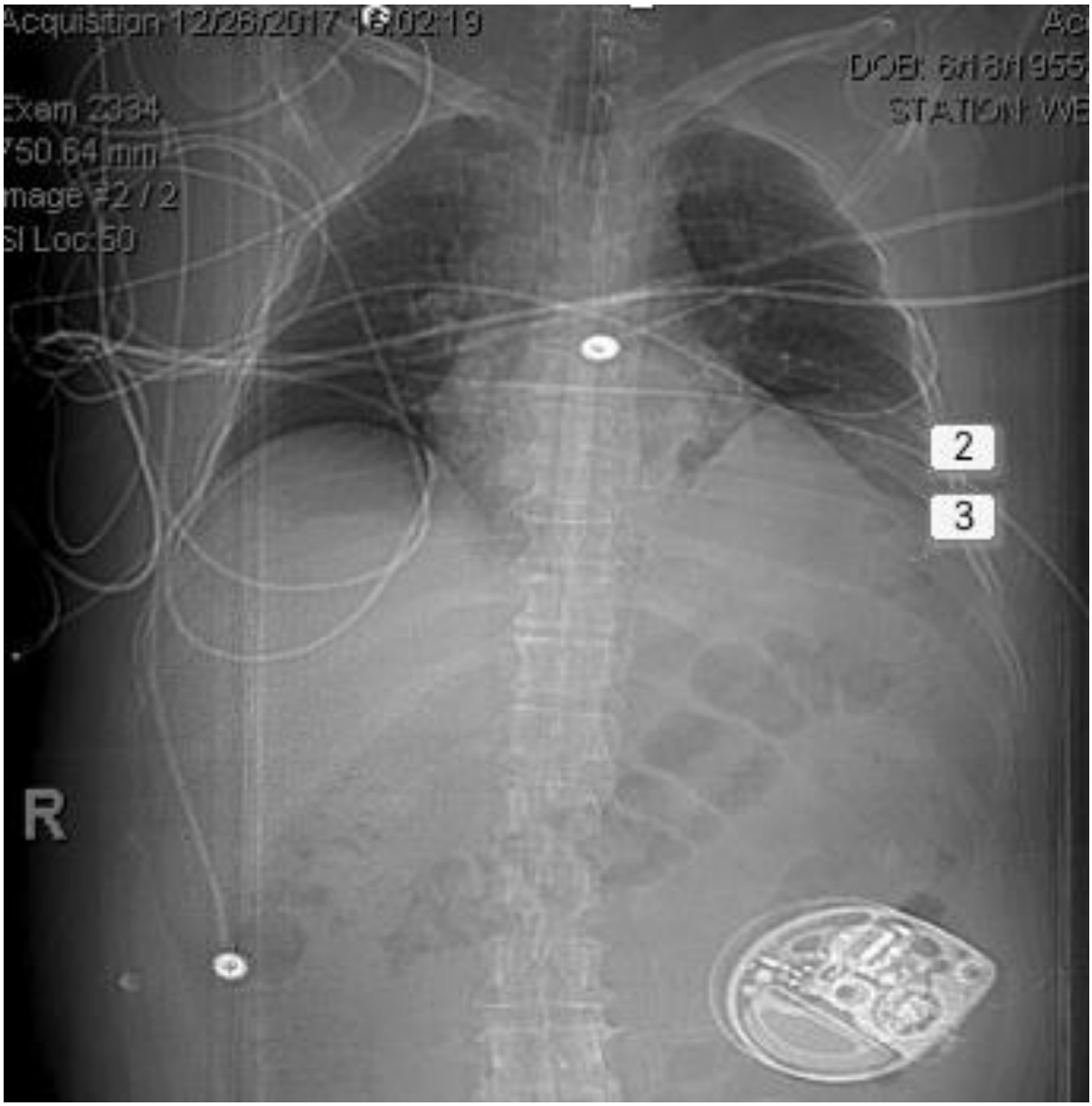

Fig. 2. Patient intubated and sedated in ICU with SynchroMed II pump in situ.

64% claims, the majority of them, 61% (25/41) were due to medication management issues (7). Fitzgibbon et al (7) further reported that severe injuries were significantly higher during maintenance of IDDS than during the surgical procedure of implanting the device (32% vs 8%). This included injuries such as permanent neurological damage (24% vs 16%) and severe brain damage and death (32% vs 8%). There are other complications associated with IDDS such as infections (23%), granuloma formation, meningitis, cauda equina syndrome (9%), retained catheter fragments (9%) and inadequate pain relief, but the rates of these complications is also significantly lower and moreover are easier to manage than the potential

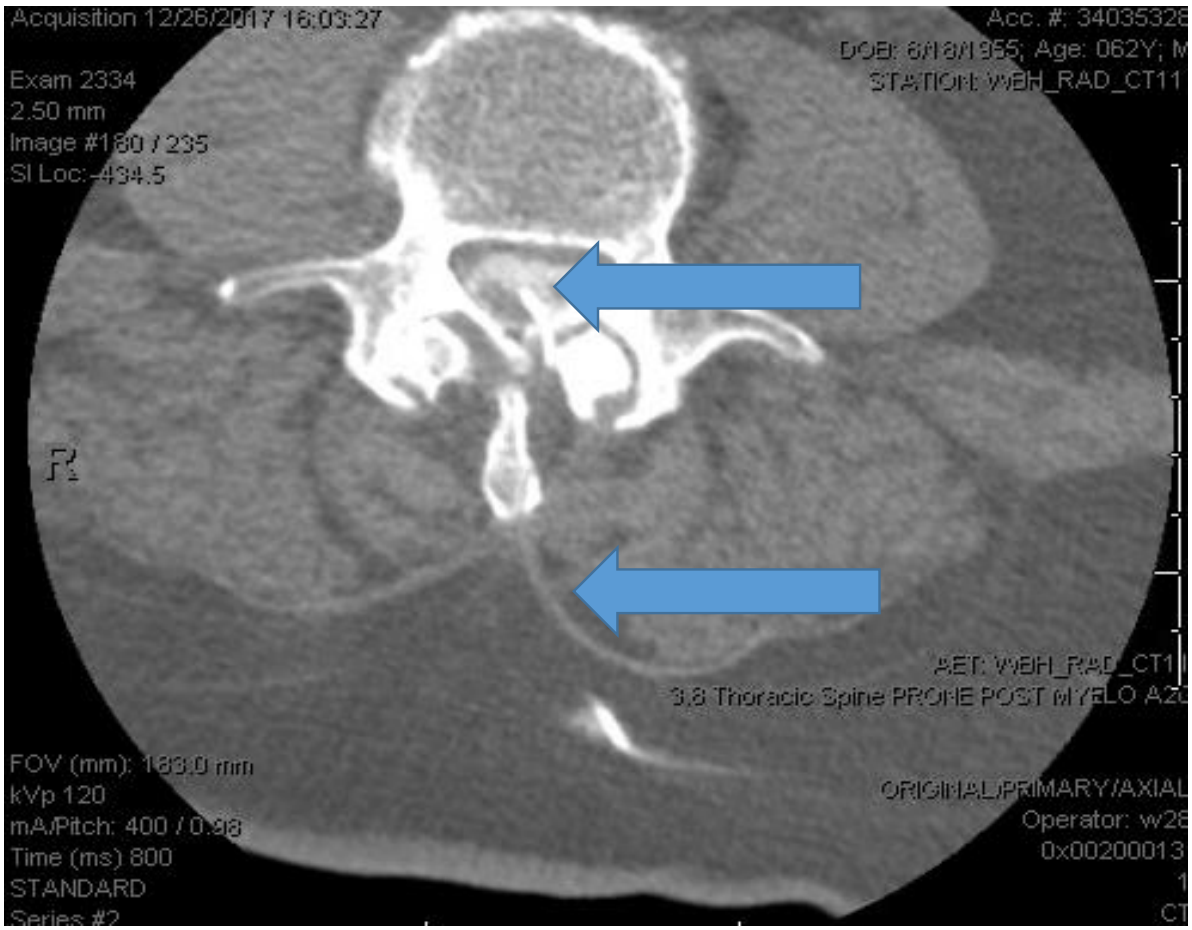

Fig. 3. Computerized Tomographic Images of Spine: Blue arrows show intact intrathecal catheter.

for catastrophic neurological insult during the refill procedure of an IDDS. Morbidity and mortality associated with maintenance of IDDS can be minimized by following established protocols for refilling and reprogramming, and appropriate patient follow-up (7,8). To reduce the risk of drug-related errors, particular attention should be paid to the proper functioning of pump hardware, drug reservoir volume discrepancies and overdose symptoms reported by patients. Furthermore, the clinician should be prepared for drug errors and follow the risk mitigation flowchart mentioned in the clinician refill reference card provided by the IDDS manufacturer (9). Before the refill procedure, it is advisable to always verify that the correct kit, injection port and order form for the medication to be deposited in the reservoir are used. The clinician should always open the kit himself so that the warning messages on the kit are not overlooked. It is advised that 2 clinicians should independently check the kit, template, and medication. The template provided with the refill kit should be used for locating the reservoir injection port instead of palpation, which can be subjective (Fig. 4). During the process of drug refill, the clinician should validate the puncture into the reservoir by aspirating the estimated volume of medication remaining before refilling the pump. Then small amounts of the medication (3 -5 mL) should be injected and aspirated into the reservoir before the pump is refilled with the entire dose. Furthermore, the full volume injected should be readily aspirated and colorless. In case the aspirate appears not to be a medication, then it should be tested with a reagent

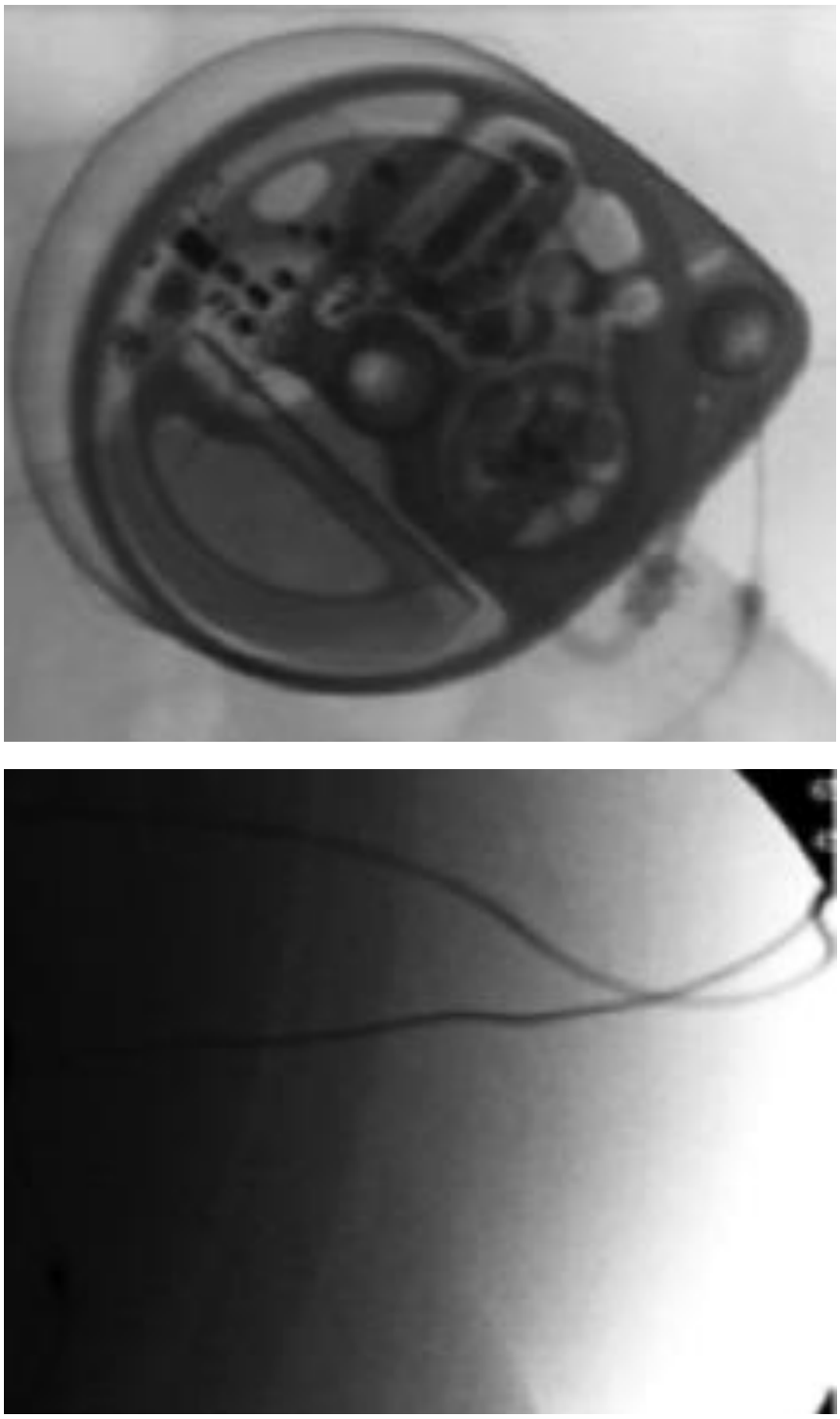

Fig. 4. Fluoroscopic images: Side port study showing intact connection between catheter and catheter access port (above) and image of intact catheter without leak (below).

strip for glucose and protein to indicate that CSF has been aspirated (10).

To further improve the accuracy of locating the reservoir injection port, imaging modalities such as fluoroscopy or ultrasound can be employed. Various components of the IDDS, such as catheter and pump roller, should be scrutinized to rule out hardware malfunction (9,11). In order to ascertain the structural integrity and continuity of the catheter to the intended site in the spinal cord a side port study can be conducted. Under aseptic precautions and anteroposterior fluoroscopic guidance, a catheter access port kit is used to access the side port that is connected to the intrathecal catheter. Using a syringe, fluid is aspirated to make sure that all the medication inside the catheter is removed. Then 1-2 mL of contrast dye is injected and analyzed fluoroscopically with particular attention to disconnections between the catheter and the pump, leakages and kinks, along the catheter as well as confirmation of intrathecal spread of dye at the distal end of the catheter. Once the continuity of the catheter is confirmed to be intact, then the physician can proceed and program a priming bolus, as per the implant manual to advance the intrathecal medication to the catheter tip. Once a full system priming bolus is delivered, it is recommended to monitor the patient with

pulse oximetry for 24 hours, in a facility equipped with emergency resuscitative abilities including naloxone for opioid overdose (10,11).

The rotor of the IDDS pump has the role of controlling the dose of medication delivered as the drug is delivered via gas-driven bellows of reservoir of the IDDS. It is imperative to perform a rotor study to rule out pump roller malfunction and to make sure that the intrathecal medication is delivered precisely as programmed. The rotor test can be performed under fluoroscopic guidance or by using x-rays, especially using overexposed film, can help in locating and visualizing the pump and the roller more easily, following the instructions given by the IDDS manufacturer (12). A catheter access port kit is employed to access the port septum. The physician should calculate the amount of medication bolus required to move the roller of the pump by 90 degrees. This can be achieved by first identifying the calibration constant from the pump program screen or from the device identification card. Dividing 1,800 by the pump constant will yield the volume of medication in microliters to move the roller by approximately 90 degrees. In order to convert the bolus volume to present metrology, multiply it by the drug concentration and then divide it by 1,000. If the result obtained can lead to overdose, then 1-2 mL of the drug solution can be aspirated from the catheter via the catheter access port. The pump is then programmed to deliver the calculated dose in approximately 1 minute which will cause the pump roller to turn 90 degrees. X-rays can be used to confirm the new position of the pump's roller or alternatively, fluoroscopy can be used to visualize the dynamic motion of the pump roller by 90 degrees. If the movement of the roller is not as expected, then the device might be stalled. In that scenario it is advised to forego the pump refill and contact the manufacturer for further troubleshooting. The SynchroMed II pump also records rotor stall and recovery in an event log which self reports upon interrogating the pump. If the movement of the rotor is not as expected, either during fluoroscopic test or as reported upon interrogation, then it is advised to forego the pump refill and contact the manufacturer for further troubleshooting (13). If the pump rotor study is within normal limits, then an appropriate priming bolus must be performed to advance the medication in the catheter. Furthermore, it is of paramount importance that the institution should have written guidelines for early recognition of a drug-related error (leg pain, seizures, etc.). Pocket seromas can be mistaken for pump fluid leading to deposition of IDDS drug solution in the seroma cavity. Strategies to minimize but not eliminate pocket refills include adequate training and use of image guidance to identify relevant refill port. Furthermore, when the needle is engaged in the port cavity, it gives a firm, tactile feedback with increased stability of the needle in contrast to unstable and yielding motion of the needle when it is in seroma cavity. A complete aspiration of medication from the reservoir with significant discrepancy from expected value (> 1 mL for 20 mL IDDS reservoir or > 2 mL for 40 mL IDDS reservoir) should raise suspicions of a potential pocket refill (14). If an error due to IDDS is suspected then, depending on the clinical condition of the patient, treatment in an urgent or emergent fashion, such as active irrigation and drainage of the CSF, respiratory support, and small incremental doses of opioid reversal agents, should be instituted (15).

CONCLUSION

In conclusion, serious outcomes including death or permanent brain damage may occur from medication administration errors, primarily during maintenance of IDDS. The importance of understanding the IDDS and competency in performing pump refills and programming is of critical importance. Formal courses and educational material is available online for the physician to become familiar with IDDS and it is advised that trainees should perform 20 supervised refills before conducting the refill and reprogramming alone. The clinicians involved in the ongoing care of patients with IDDS should undergo periodic competency validations. Imaging modalities are useful adjuncts for intrathecal pump refills with a more difficult entry or previous complications at the time of refill. A rapid recognition of evolving complications and implementation of appropriate treatment are the cornerstones of successfully managing complications associated with refilling of IDDS. In the case of inadvertent intraspinal injection of an IDDS drug, it is of paramount importance to adequately counsel, and reassure the patient about the pathophysiology to allay anxiety and any increased emotional suffering.

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