Chapter 41.
HIGH LEVEL TECHNOLOGY:
Identify Drug-SYRINGE and SOLUTIONS.

INDEX.

(These are cuttings from the full chapter in the printed book.)

------- ---------------

1. INTRODUCTION

Fixing systems to help prevent Anesthesia Medication Administration Process (AMAP) errors is crucial. Ideal technologies will verify three steps: (a) verify the anesthesiologist selected the exact drug ampule they intended to select, (b) the syringe label matches the drug ampule label from which the syringe content was aspirated, and (c) the drug syringe about to be injected is the one intended to be injected, and via the right route. Every verification must be able to be entered into electronic medical records. Additionally, the end users could spectroscopically verify that the content of the manufacturer's ampule matches the ampule label.

The VEINROM system, incorporating high-level technologies such as Spectrometry, Bar Codes, and RFID tags, is designed with the end user in mind. The challenge is to create a system that is cost-effective, compact but also user-friendly, and ergonomic. The aim is to simplify the AMAP process for anesthesiologists, reducing complexity and enhancing safety.

RFID reading at the intravenous injection site is the best target for future development. Good **ERGONOMICS** if the biggest design priority.

2. The VEINROM system.

(The book's full chapter has 22 pages and 26 references)

3. SPECTROMETRY

Spectrometry measures the absorption and emission of electromagnetic waves by matter. It can analyze the chemical nature, traits, and forms of chemicals and substances. There are many types of spectrometers. They easily recognize the wrong drugs and general concentrations[1].

Image no. 2. Spectroscopic scanning a drug vial.

Spectrometry has a deeply embedded and long-standing role in the pharmaceutical industry, particularly in the development process of discovering and manufacturing new drugs. It is also used in Canada and Europe at help centers for street drug abusers. The street drug abuser presents the batch of medications they have purchased, and the help center tests it to confirm it is the correct drug and verify its potency. The help centers use spectrometers, and fentanyl and cocaine are easily identified. This saves street drug users' lives, for example, by revealing that fentanyl is an unanticipated component of the street drug. This street-drug verification service at the help center is used to lure street-drug addicts in and to bring them close to persons willing to help them psychologically and medically.

Image no. 3. Hand-held spectrometer.

Image no. 4. Scanning the chemical/drug contents of a bottle.

Some spectrometry technologies destroy the sample and are thus unsuitable for clinical use. Some technologies are very usable even without a highly trained technician needing to be present. The technologies with the potential to identify anesthesia medical drugs are **Infrared** Spectrometry, **Ultraviolet** Spectrometry, and **Raman** Spectrometry. *The one that might be the most suitable for anesthesia point-of-care applications is **Raman** Spectrometry.*

Raman Spectroscopy is a non-destructive chemical analysis technique that provides detailed information about chemical structure. A Laser beam is shone onto or into the substance under review, and the reflected electromagnetic energy is analyzed for a signature "fingerprint" or format that identifies the tested substance precisely. Raman spectroscopy is used to identify counterfeit drugs without opening the packaging. It is used to monitor anesthesia and respiratory gas mixtures during surgery. The technology has been tested to analyze drugs in patient intravenous infusions, but no product is yet commercially available[2, 3].

Raman refractometers can monitor drugs in an intravenous solution but are poor at distinguishing NaCl from KCl solutions. If solution analysis is required, an additional Raman refractometer must be built into the device to identify electrolyte solutions. A result is available within seconds, in virtually real-time.

(The book's full chapter has 22 pages and 26 references)

(The book's full chapter has 22 pages and 26 references)

4. BARCODE SCANNING

Barcodes are visual structures printed on an optically readable surface. Barcodes were based on Morse code and were patented in 1952. It is a method of representing data using black parallel lines on a white background. The lines have varying widths, spacing, and sizes that special optical scanners can read. Barcodes only became popular when the supermarket system started using them for product checkouts in 1972. The coded data contained the product sale price and other information to be entered into a computer database after scanning. The store would instantly know the sales numbers of all products, have automated recording of replacement produce needed and a calculation of all accounting matters, all near instantly. **The American FDA mandated in 2003 that all human drugs and biological packing have a barcode containing identification and details of the biological**[11]. The intention was for that information to be accessible at the Point-of-Care.

(The book's full chapter has 22 pages and 26 references)

5. RFID-tag technology - THE BIG FUTURE.[17]

The microchip embedded into modern credit cards requires being close enough to the **RFID** reader for the credit card to be touching the reader (tapping it). It allows keeping full control of the credit card in your hand and complete the payment with ease. This is **R**adio **F**requency **I**dentification **D**evice (**RFID**) technology. The microchips for RFID can be made so small they can be embedded within a label applied to a drug syringe. **See images number 8 and 9**.

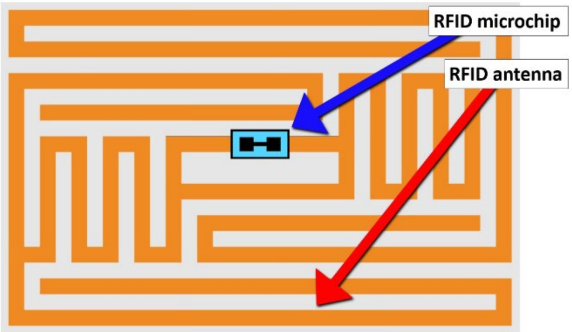

Image no. 8. Typical credit card type RFID tag.

Radio Frequency Identification (RFID) tags are ubiquitous in life. They are alternates to barcode and QRS-code scanning to hunt object data. RFID tags are now a standard part of (i) all credit cards, (ii) vehicle toll road passes for automatic payments and stuck inside the vehicle windshield, (iii) injected into pets to identify lost animals, and (iv) embedded into worker name tags for giving automated access to secured spaces. RFID tags will never replace barcodes because of the two technologies; only bar codes (i) can be transmitted digitally by e-phone and email, and (ii) are virtually costless. RFID is, however, a tremendous *complementary technology to bar codes*.

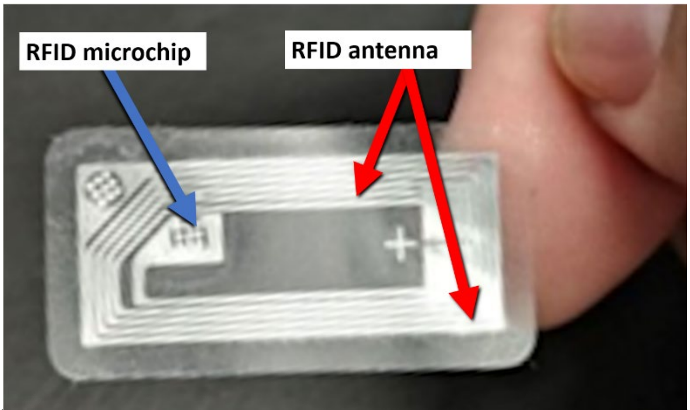

Image no. 9. An **RFID** tag that can be integrated into a drug label.

Of foremost interest is the utility of RFID tags to massively optimize anesthesia drug administration safety. Tags can be produced for only a few US cents, but the RFID readers and supporting technologies will add new costs and layers of technology sophistication to operating rooms.

RFID chips can be part of a *drug syringe* within the drug name label. The RFID chip facilitates automated identification during the drug injection process. RFID tags can also be part of a *drug container* (fluid bag, vial, ampule) to verify its contents when it is selected from storage.

RFID chips' biggest advantage is their potential to dramatically improve anesthesia drug safety **without adding to the workload and ergonomic challenges** anesthesiologists face. Anesthesia work efficiency will be improved, not worsened as barcode readers do. An RFID-chipped labeled syringe must only be passed across a chip-reader device label with one hand holding the syringe to trigger all the automated drug safety procedures. Using the second hand to hold or trigger a barcode reader is unnecessary.

What are RFID tags?

RFID tags have three components: (i) a microchip, which is an integrated circuit that stores information [the microchip]; (ii) an antenna for receiving and transmitting radio signals; and (iii) a **substrate** to hold or encase the antenna and chip. The RFID tag is attached to the object that it has to identify. A two-way radio device called a *reader*, an *interrogator,* or a *scanne*r sends a signal to the RFID tag and then reads the tag's returned radio signal. The tag's main objective is storing information. **See images number 8 and 9**.

Common tags are *read-only* types, but a sophisticated tag can process information transmitted to it. The radio frequency that interacts with the tag determines the minimum distance between the tag and the reader for them to interact. The lowest frequency RFID tags need the closest contact to the RFID reader/scanner. Ultra-high frequency tags make it possible to scan all tagged inventory at once within a warehouse. The tag's antenna size has a small adjusting influence on the tag-interrogator range. Bigger antennas allow for longer-range interrogations. The range may be zero, with tag-interrogator touching required. The reader-to-tag communication distance to trigger RFID tag reading can be designed to be 1 cm, 5 cm, or any selected distance up to 200 meters, depending only on the selected chip frequency range and the antenna size design.

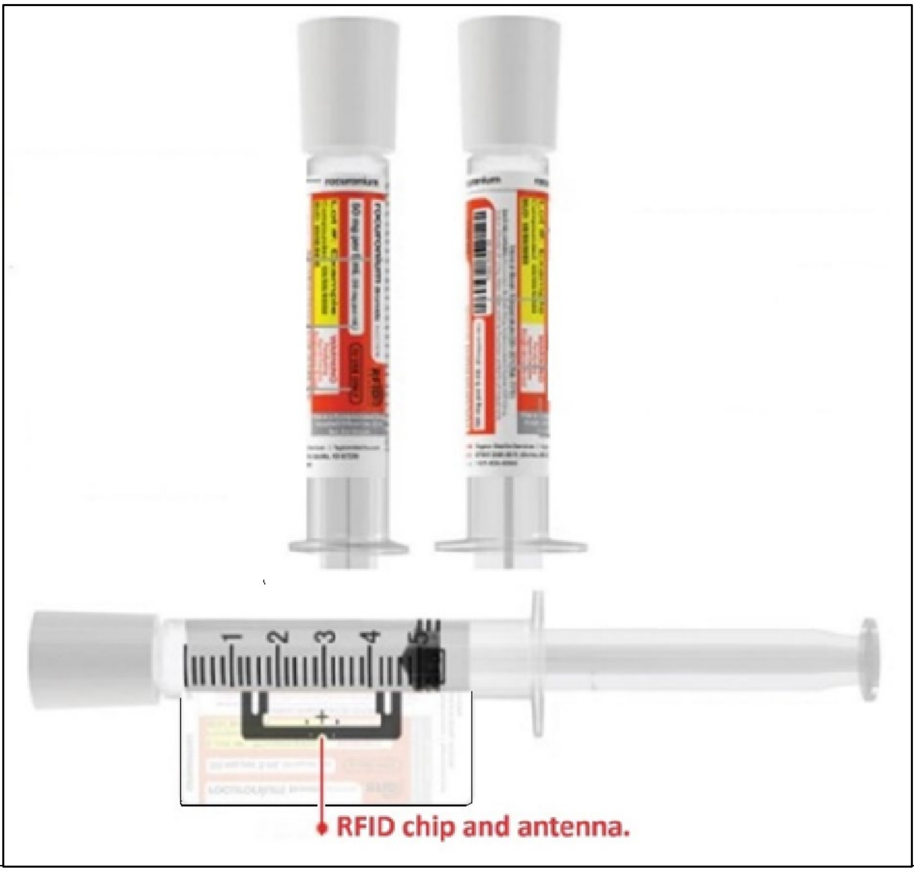

Image no. 12. Adhesive label with an RFID tag attached to syringes. The actual RFID chip is very small and its associated antenna is thin enough to be rolled around the syringe. The label can also be designed to be attached, sticking out to the syringe's side, like a flag. That spares covering the syringe volume markings.

There is much potential for further design refinement and fine-tuning of anesthesiologist working ergonomics. Final evidence of improved patient safety is the big goal and should be the leading consideration in assessments and design improvements. Cost matters will decide if such systems can be implemented in all operating or intervention locations where anesthesia or sedation is administered in all sizes of big city health institutions or rural small hospitals. It must be emphasized that drug RFID labels for product tracking and inventory control have nothing to do with medication injection safety and syringe preparation during those clinical procedures.

For Anesthesia Medication Administration Processes (AMAPs), a different RFID microchip is needed that only reacts upon close proximity or tap scanning to an RFID reader in the patient injection process. The RFID reader can be positioned at the location where injections are given, e.g., on the same arm board where the patient's armrests with the intravenous line. **See image number 14** of a small RFID reader for credit cards.

Image no. 14. A RFID reader is small and does not need to be touched. It is adaptable and can be placed where most ergonomically convenient for the anesthesiologist when administering injections.

Differences between BARCODE, QRS-code, and RFID chip scanning.

Barcode and QRS-code scanning both require a **line-of-sight** to the reader/scanner and use **light beams**. RFID scanning uses electromagnetic radio waves sent from the scanner to the RFID chip, generating a return second radio signal from the passive RFID tag back to the scanner. The returning radio signal conveys the pre-set information contained in the RFID tag. A line of sight is not generally needed. However, it can be closely simulated using radio-signal blocking materials built around the scanner except for the part facing the RFID-tag-labeled item. That will prevent accidental RFID scanning from the reader's side.

Generally, barcode reading is more accurate and reliable than RFID if scanned from a distance. Implementing RFID reading technology is more expensive and complex than barcode reading technology. RFID tags, however, can be produced cheaply. The precise RFID technology to be used depends on the reading distances needed and the objectives of RFID use. Very careful thought is needed when designing a new system. Barcode reading is old technology.

Using both BARCODES and RFID tags.

The big decision is not necessarily to choose between bar codes and RFID technologies in the long, complex Anesthesia Medication Administration Process (AMAP). Both technologies can *complement each other*. Barcodes can be placed on vials, ampules, and fluid bags to identify the contained substances at a practical zero cost. A mounted fixed bar code scanner can be placed up the anesthesia cart work surface. Any pharmacological item with a barcode could be passed before the scanner, and the anesthesiologist would instantly receive an auditory announcement of the medication and visual information on an adjacent computer touch screen. An RFID label can be immediately printed. The immediately printed RFID-containing adhesive label can be applied to the syringe. Then, a fresh cycle can be initiated for the next injectable medication preparation.

When actual administration of the medication occurs, the RFID-labeled syringe can be touched against a small RFID reader that will speak back the syringe drug content and enter the medication and its administration time into a computerized medical record system. The RFID reader can be battery-powered and linked to the computer via Bluetooth or wire-linked via a USB port. The reader/scanner can be situated at the most convenient point, strapped to a patient's arm, resting on the anesthesia cart, or wherever is most efficient, convenient, and ergonomic for the anesthesiologist.

All the barcode and RFID drug checks mustn't add to the anesthesiologist's workload but rather enhance, simplify, and improve medication administration safety.

Many tech companies are expanding and developing uses for RFID technology in healthcare[21].

GenixusTM has started introducing Ready-To-Administer (RTA) anesthesia drug syringes with RFID chips associated with the KinetiXTM RDIF inventory scanning systems company. The RFID chip is embedded in the tamperproof syringe cap. The syringes also have color codes on the syringe plunder shafts to identify the drug function grouping. **See image number 16.**

Image no. 16. Genixus™ Propofol and rocuronium syringes. The RFID tag is in the syringe cap.

6. The *Kit Check*® RFID system.

Kit Check® is a company that uses RFID technology primarily to manage hospital PHARMACY INVENTORY CONTROL. Its services and products are evolving.

Currently, for anesthesia, they have a system where a storage tray of anesthesia drugs is scanned inside the cabinet. Each vial of the factory-compounded drug syringe has an RFID label that the scanner can read. It can be determined what drug items need replenishing and if any items are expired. It reduces human labor greatly, saving pharmacists hours each day. All inventory information is available at any time on a linked computer. More and more drug manufacturers produce ready-to-inject drug syringes, and the RFID tag is embedded in the syringe's tamperproof cap.

(The book's full chapter has 22 pages and 26 references)

(The book's full chapter has 22 pages and 26 references)

11. CONCLUSION

Spectroscopy, particularly Raman spectroscopy, has the potential to identify the actual drug within a container in the anesthesia setting. The ideal would be if a device could be designed that would place a syringe with a drug and a label on it or in it that could verify the label (via a bar code scan) matched the syringe's content within 3 seconds. No such device yet exists, nor seems likely to be ever available. It could be part of a syringe smart pump for controlled medication infusions.

Not all spectroscopic technologies are usable on a drug to be administered to a patient because some devices damage the measured substance. There is a need for accuracy, time efficiency, and preservation of the analyzed sample conflict. Sample preservation requires low-energy laser beams, and accuracy and speed require high-energy laser beams that damage the sampled drug.

The *anesthesia workflow must be very time efficient*, and scanning that requires minutes to produce a result is unusable. If syringes were pre-prepared in a hospital pharmacy compounding unit, and spectroscopy was used to verify the syringe label and contents were matching, that would be valuable in helping reduce some anesthesia drug errors. That would be expensive and require extra trained pharmacists, workspace, and equipment. It would likely not be economically feasible in small clinics and small rural hospitals. Only drugs highly expected to be used within the safe shelf life of the freshly prepared syringe could be pre-prepared and scanned. Many anesthesia drugs are only prepared when an anesthesia indication for drug use arises. Often, the drug must be administered within seconds.

The best technology remedies to optimize Anesthesia Medication Administration Process safety would seem to be the widespread use of barcode scanning of medication and fluid vials, ampules, and bags to verify the correctness of the agent in storage or hand. That should be combined with RFID identification of the drug-containing syringe in hand in the final injection process.

As a closing point, an Australian national newspaper, ***The Sydney Morning Herald,*** reported some patient fatal drug mix-ups to the public on May 4, 2019. There was pending Australian legislation to force more safety regulations onto medication manufacturers.