LOW-COST REMOTE DRUG DELIVERY BLOW-DART FOR VETERINARY USE

***Tarmizi, M.R. & Zainuddin, Z.Z.**

Borneo Rhino Alliance, c/o Fakulti Sains dan Sumber Alam (FSSA), Universiti Malaysia Sabah, Malaysia.

*Corresponding author's email: reza2727@gmail.com

ABSTRACT

Remote drug delivery system (RDDS) is commonly used by veterinarians to administer drugs to the unapproachable captive zoo and free-ranging animals. Although several commercial systems are available, they are expensive to purchase. The construction of a low cost, home-made two-chambered compressed air blow-dart is described in this paper for the use of veterinarian in developing countries. The design of the dart is based on the design of a commercial blow dart system. An advantage in terms of cost-effectiveness is expected when the darts are applied in mass, for example rabies vaccination program on free-ranging stray dogs where a large number of darts are required or immobilization in macaques for biological sampling where darts are usually damaged.

Keywords: Remote drug delivery system, zoo, low-cost, veterinarian, sustainable blow-dart.

Received (06-March-2019); Accepted (08-July-2019); Available online (25-August-2020)

Citation: Tarmizi, M.R. & Zainuddin, Z.Z. (2020). Low-cost remote drug delivery blow-dart for veterinary use. *Journal of Wildlife and Parks,* **35**: *39-48*

INTRODUCTION

The ability to inject a drug into a free-ranging animal using a remote injection system is a mainstay of the practice of zoological medicine (Bush, 1992). There is a various range of remote drug delivery system in the market, but the most basic system is the lung powered propelled blowpipe system. The major advantage of this blowpipe system is a silent projection with minimal trauma upon impact. It is adaptable for use on small animals, easily sighted, and has no mechanical parts to malfunction or that require maintenance (Fowler, 2011). These blowpipe systems are produced commercially by various manufacturers including Telinject, Dan-Inject, Maxi-Ject and TeleDart which consist of an 11 mm or 13 mm internal diameter (ID) blowpipe barrel, a mouthpiece and a blow-dart.

All blow-darts have four basic components: a drug storage compartment, a mechanism for injecting the drug, a needle to penetrate the skin, and a stabilizer for accurate flight (Isaza, 2014). Blow-darts are difficult to clean and sterilize after each use because they are a self-contained unit. They are also frequently destroyed when an animal bites into them following darting and have limited range and drug volume (Bush, 1992). Commercially produced darts are made with precision and manufacturing are done outside South East Asia (S.E.A), making the product expensive in S.E.A. developing countries. For developing countries, limited funds and high cost in importation makes it unsustainable for frequent use. Thus a home-made dart would be a more practical alternative for these reasons. Several home-made dart and projector systems with improvements have been described in previous literature (Brunson & Cooley, 2018; Corson *et al*., 1984; De Vos, 1979; Haigh & Hopf, 1976; Reddacliff, 1979; Warren *et al*., 1979). These previously described home-made blow-darts uses a single syringe which limits the drug chamber volume or uses larger syringe size to compensate that would not fit into an 11 mm -13 mm ID barrel. In this article, the making of two-chambered air blow-dart is described. The dart would have a maximum of 3 ml drug chamber and will fit into any commercially produced or self-procured blowpipe with an 11mm ID barrel. The construction uses locally available materials found commonly in hardware stores, online stores and veterinary supplies.

MATERIALS AND METHODS

The Method in Preparation of Blow-Dart

Dart body

List of tools and materials are listed in Table 1. Firstly, prepare the drug chamber barrel by using a 3 ml luer lock tip syringe (Axis, Wuxi Medical Appliance Co. Ltd) and remove the plunger rod. Remove the rubber plunger apparatus from the plunger rod by cutting it flush at the attachment point using a razor blade. Replace the cut rubber plunger back into the syringe barrel. Trim off the syringe flange with a razor blade, leaving a smooth and even cut edge. The author uses a custom-designed 3D printed syringe cutting tool adaptor to achieve a straight cut edge (Figure 1a). The end product should look as in Figure 1b.

Table 1 Tools and material.

Designator	Component	Quantity	Source of materials
Drug chamber	3ml luer lock tip syringe (Axis)	1	Veterinary supply
Air chamber	3ml luer slip tip syringe (Terumo)	1	Veterinary supply
Air syringe	25ml luer lock tip syringe	1	Veterinary supply
Dart needle	Hypodermic needle 18G 1 1/2"	1	Veterinary supply
Needle bore	Hypodermic needle 21G 1"	1	Veterinary supply
Dart needle sealer	Rapid steel epoxy	1	Hardware store
Adhesive glue	Gorilla super glue	1	Hardware store
Solvent	Xylene	1	Laboratory supply
Welding tool	Ceramic heater soldering iron	1	Hardware store
Tailpiece	Knitting yarn	1	Craft or hobby shop
Tailpiece base	Grommet	1	Craft or hobby shop
Cutting tool	Syringe cutting tool adaptor	1	https://3dprint.nih.gov
Cutting tool	Razorblade	1	Hardware store
Cutting tool	Cuticle nipper	1	Personal care store
File tool	Diamond file set	1	Hardware store
Tailpiece tool	Flea comb	1	Personal care store
Tailpiece tool	Toothbrush	1	Personal care store
Barrel guide	Aluminium U channel 10 x 10 x 200mm	1	Hardware store
Syringe connector	OD 6mm, ID 4mm high-pressure water flex tube	1	Hardware store
Non-return valve	Silicone rubber plunger/stopper (used)	1	Dental practice

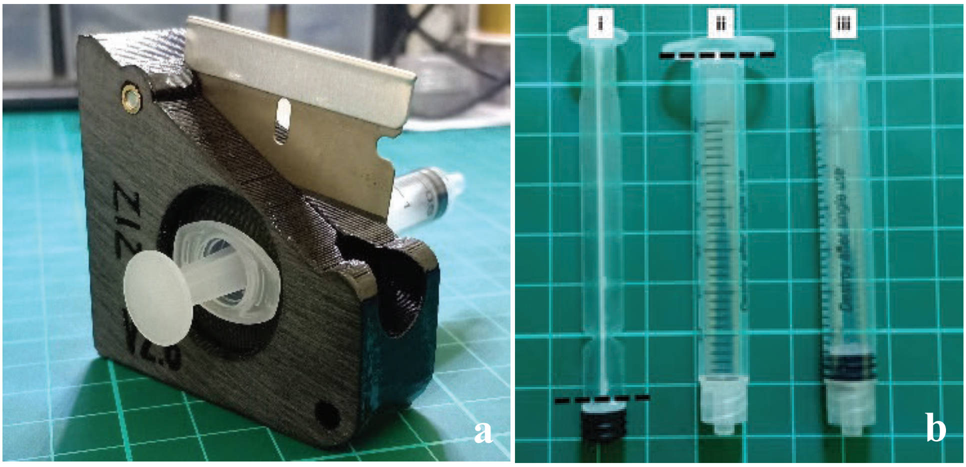

Figure 1 (a) Syringe cutting tool adaptor; (b) Preparation of the drug chamber barrel. i. Rubber plunger apparatus cut at dash line. ii. Trim off syringe flange. iii. Replace rubber plunger into syringe barrel.

Next prepare the air chamber barrel by using the 3 ml luer slip tip syringe (Terumo, Terumo Corporation). Remove and discard the whole plunger rod. Trim off the syringe flange with a razor blade, leaving a smooth and even cut edge. Insert a non-return valve, which is made of 6 mm x 7 mm silicone rubber stopper used in glass cartridge which was salvaged from a used dental anaesthetic cartridge (Xilonibsa 2% 1.8 ml, Inibsa dental) (Figure 2a). Alternatively, the valve could be made by punching through an 8 mm thick silicone sheet with an 8 mm biopsy punch. It is important that the non-return valve is 6 mm or more in thickness. The end product should look as in Figure 2b.

Apply polypropylene solvent, xylene around the cut rim edges of each syringe barrel using a cotton Q tip. Apply even heat to the cut rims simultaneously. The author uses a ceramic heater soldering iron set-up to 300 - 350°C. The rim surface of the barrel is heated evenly by rolling each barrel until the rim edge changes its shape to a tubular shape indicating the solvent action has taken place (Figure 3a). Attach both syringe barrels by aligning and pressing against both rims edges creating a “solvent-weld” joint. An aluminium U channel is used as a guide to achieving straight alignment for solvent-welding (Figure 3b). Any excess extruded polypropylene can be trim flush with the outer dart body with a cuticle nipper. Perform a leak test by charging the dart with 15 ml of air using an empty syringe connected to the air chamber opening via a syringe connector. Submerged the dart in water beyond the level of the barrel weld joint and observe for bubbles. The dart is considered sound if no bubbles observed when charged.

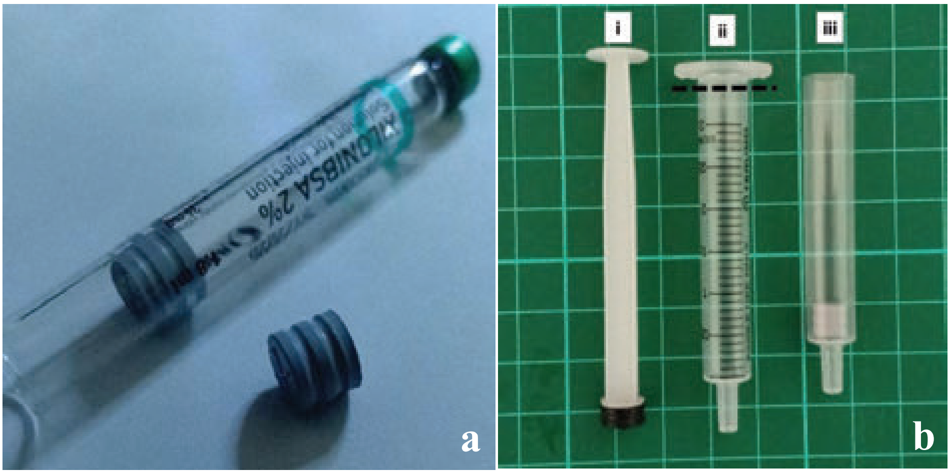

Figure 2 (a) Non-return valve is made from salvaged used dental anaesthetic cartridge rubber stopper; (b) Preparation of the air chamber barrel. i. Discard plunger rod, ii. Trim off syringe flange at dash line, iii. Insert non-return valve.

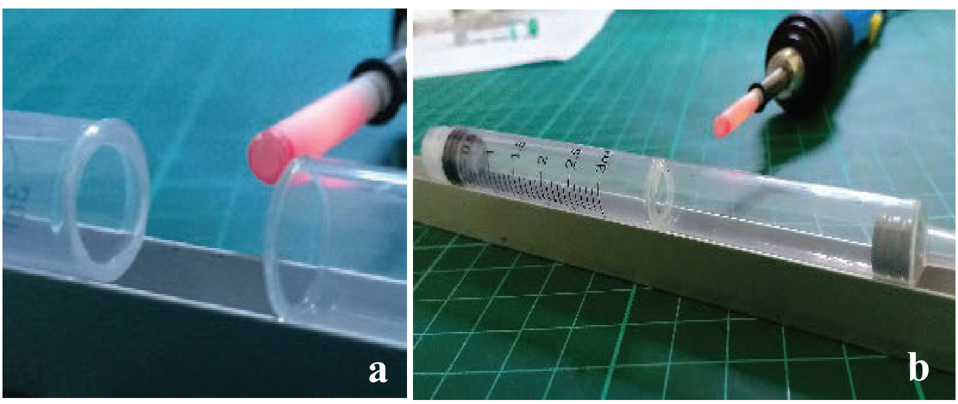

Figure 3 (a) Syringe barrel rim edges are melted by heat from a soldering iron while rotated to get an even tubular shape before welding; (b) Aluminium U channel is used to align syringe barrels during solvent welding.

Dart needle

The preparation of the needle is as described by Haigh & Hopf (1976), and the process is summarized here. Seal the opening tip of an 18-gauge needle by filling it with epoxy glue and leave to cure base on manufacturer recommendation. An alternative to epoxy glue is by soldering. Perform a leak test by infusing water through the needle. Water should not be observed at the sealed needle tip when water is infused and resistance is felt. Proceed by making a side hole on the side of the needle, by filing across the needle shaft with a diamond file or a Dremel™ tool to a depth just enough to bore a hole through using a 21-gauge needle. The side hole is positioned 1cm from the tip of the needle. A commercial silicone sleeve will be needed to occlude the side hole when the needle is prepared before use. A silicone lubricant is used to allow smooth movement of the silicone sleeve along the needle shaft.

Tailpiece

The tailpiece is prepared by making 10 identical loops using knitting yarns. This can be achieved by looping around an aluminium U channel as a guide. The loops of yarn are tied together with two overhand knots and are then attached to a grommet using adhesive glue (Gorilla glue, The Gorilla Glue Company) (Figure 4a). The loop or yarn is then cut to single strands and teased using the flea comb and made fluffed using toothbrush (Figure 4b).

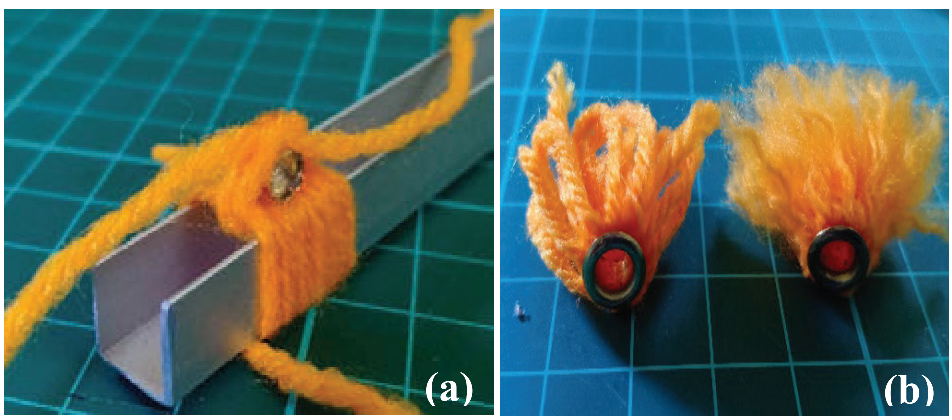

Figure 4 (a) Two overhand knot on a grommet; (b) Yarn loops (left) will be cut to strands and further broken into smaller strands in preparing the finished tail piece (right).

Assembly

The complete assembly of the dart is as in Figure 5.

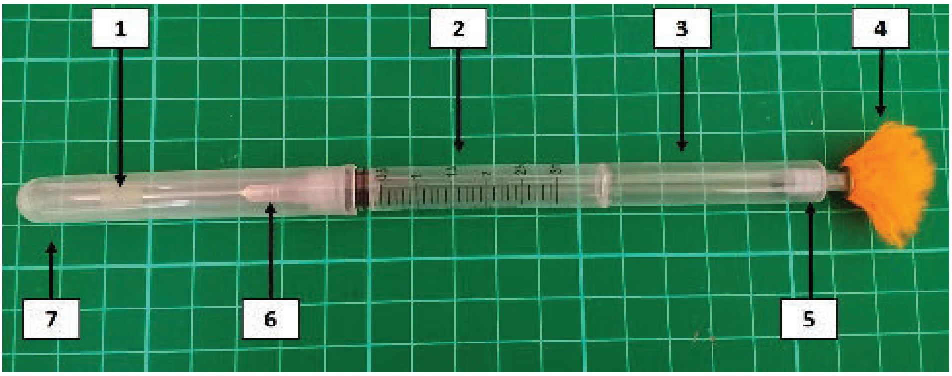

Figure 5 Complete assembly of the low-cost dart. 1. Silicone sleeve on side hole, 2. Drug chamber, 3. Air chamber, 4. Tailpiece, 5. One-way valve, 6. Needle, 7. Safety cap.

Using of blow-dart

To prepare a charged dart, calculate the drug volume required and load the drug chamber to the volume desired. Mount the dart needle with a silicone sleeve on the luer lock hub. A safety cap made of a 3 ml disposable test tube is placed over the end of the needle until the dart is ready to be charged. Pressurize the air chamber with 10-15 mls of air using an empty syringe connected to the air chamber opening via a syringe connector with the dart in a vertical orientation and the drug chamber facing up. The non-return valve will become compressed against the air chamber creating a "dishing effect" which indicates a charged dart. Finally, attach the stabilizer on the luer slip hub.

The dart could be used with any commercial blowpipe system or a self-made blowpipe easily procured by using carbon fibre or aluminium tube of 11 mm - 12 mm ID attached to a mouthpiece. The author uses a custom-designed 3D printed mouthpiece with a 14 mm ID.

A sharp puff of air blown through a mouthpiece is sufficient to project the dart up to 3-4 meter with good accuracy. This system is best used for distance ranged from 3 to 5 m. As the dart strikes the animal, the silicone sleeve covering the side hole on the needle would be pushed backwards, freeing the side hole from occlusion. The compressed air in the air chamber will propel the rubber plunger in the drug chamber forward allowing the drug to be delivered.

RESULTS AND DISCUSSION

The construction of the described blow-dart is easy to make and can be made by non-veterinary personnel's (e.g. veterinary assistant). The final product would have a total weight of 4 grams (unloaded) and it could accommodate a maximum of 3 ml liquid in the drug chamber. The length of the dart body is approximately 130 mm. A preliminary test conducted showed that the dart would be able to withstand air pressure of 2 bars when charged with 15ml of compressed air and the drug delivery rate is around 3ml/sec. With practice, the total time to produce a dart body takes about 5 minutes, the tailpiece at about 7 minutes and the needle (pre-sealed) at about 2 minutes. The material cost of the whole dart was under MYR 3.00.

It is important to wear eye protection and gloves when preparing a charged dart. A safety cap should always be placed on the dart before charging to prevent leaked needle-related accident especially when highly potent anaesthetic drugs are used.

The dart body and needle should be treated as single-use but the tailpiece may be re-used multiple times. Upon writing this article, the author has not found a reliable material to replace a commercial silicone needle sleeve.

The blow-dart construction flexibility enables it to be made for smaller volume (1.5 ml or 2 ml dart) or a smaller gauge dart needle, 21-gauge for small animals (< 5 kg body weight). For ease of dart identification and management, tailpieces could also be made in variant colours as it allows customization. The low production cost and ease of making the darts enable it to be used as a single-use and sustainable for a developing country.

Because of the light barrel weight and thin needle wall, blow-darts are meant to be projected by lung-powered blowpipes. They are most accurate when used in the indoors captive animal but has also effective in free-ranging wildlife (Laricchiuta *et al*., 2008; Larsen *et al*., 2011) and causes minimum tissue damage. The author has used the darts on numerous occasions involving anaesthetic delivery in captive primates, medium size felids, civets and sun bears. A big advantage in terms of cost-effectiveness is when this RDDS is applied on a species in mass, for example rabies vaccination program on free-ranging stray dogs or immobilization in macaques for biological sampling where darts are usually broken by animal bites and a large number of darts are required.

Blow-darts should never be used in CO_2 propelled projectors as their light construction causes erratic flight at high velocities and they often shatter on impact (Isaza, 2014).

This home-made darts has its disadvantages. The needle tip could bend or break within the muscle if the bone is hit or if the animal sits on the dart. Therefore, it must be emphasised during needle preparation; only a small bore is created just enough for a 21-gauge needle to fit in. A bigger bore will compromise needle shaft integrity.

With the described low-cost blow-dart construction, veterinarians dealing with zoological or feral animals in developing countries can use RDDS sustainably within their practice. Low-cost blow-darts can provide a cost-effective way for programs that deal with the animal in mass.

REFERENCES

Brunson, D. & Cooley, K.G. (2018). Equipment for environmental extremes and field techniques. In *Veterinary anesthetic and monitoring equipment* (Cooley, K.G. & Johnson, R.A., eds.), pp 349-363. Hoboken, NJ : John Wiley & Sons, Inc.

Bush, M. (1992). Remote drug delivery systems. *Journal of Zoo and Wildlife Medicine,* **23**(2): 159 -180.

Corson, I.D., Fennessy, P.F. & Suttie, J.M. (1984). An improved design for home-made projectile syringe. *New Zealand Veterinary Journal,* **32**(5): 74-75.

De Vos, V. (1979). Do-it-yourself remote chemical immobilization equipment. *Koedoe,* **22**(1): 177-186.

Fowler, M. (2011). *Restraint and handling of wild and domestic animals*. Ames: Iowa State University Press.

Haigh, J.C. & Hopf, H.C. (1976). The blowgun in veterinary practice: its uses and preparation. *Journal of the American Veterinary Medical Association,* **169**(9): 881-883.

Isaza, R. (2014). Remote drug delivery. In *Zoo animal & wildlife immobilization and anesthesia.* (West, G., Heard, D., Caulkett, N., eds.), pp: 151-169. Iowa, USA: John Wiley & Sons, Inc.

Laricchiuta, P., Gelli, D., Campolo, M., Marinelli, M.P. & Lai, O.R. (2008). Reversible immobilization of Asiatic black bear (*Ursus thibetanus*) with detomidine-tiletamine-zolazepam and atipamezole. *Journal of Zoo and Wildlife Medicine,* **39**(4): 558-561.

Larsen, R.S., Moresco, A., Sauther, M.L. & Cuozzo, F.P. (2011). Field anesthesia of wild ring-tailed lemurs (*Lemur catta*) using tiletamine–zolazepam, medetomidine, and butorphanol. *Journal of Zoo and Wildlife Medicine,* **42**(1): 75-87.

Reddacliff, G.L. (1979). Home-made projectile syringes. *New Zealand Veterinary Journal,* **27**(11): 249-251.

Warren, R.J., Schauer, N.L., Jones, J.T., Scanlon, P.F. & Kirkpatrick, R.L. (1979). A modified blow-gun syringe for remote injection of captive wildlife. *Journal of Wildlife Diseases,* **15**(4): 537-541.

Supplementary materials

All CAD designs that can be downloaded for 3D printing are listed below:
Syringe cutting tool STL file can be found at
https://3dprint.nih.gov/discover/3dpx-010519
Mouthpiece 13mm ID STL file can be found at
https://3dprint.nih.gov/discover/3dpx-010520
Mouthpiece 14mm ID STL file can be found at
https://3dprint.nih.gov/discover/3dpx-010521