CHAPTER-I

INTRODUCTION

Introduction

Anemia is a common disease condition of livestock in Bangladesh with common clinical sign of pale or white mucous membrane and weakness. The major etiological factors of anemia are from several endo and ecto parasitic diseases associated with faulty nutritional management. Ruminants especially cattle, goat and sheep are the most popular and abundant species in Bangladesh. Among 547.45 (in lakh number) ruminants of Bangladesh, goat population is 259.31 (DLS, 2016-2017) that play an important economic role for rural people of this country. Instead of being an important part of livestock sector, severely anemic and unhealthy animals that does not response with the general treatment, are burden for the poor farmer of our country and economy.

A thorough history, physical and hemato-biochemical examination are important in order to establish a diagnostic plan for the treatment of anemia. The complete blood count (CBC) evaluates the red and white blood cells as well as the platelets that will confirm the presence of anemia. This CBC parameter is very important to identify types of anemia either chronic or acute anemia. If a patient has chronic blood loss, this can lead to iron deficiency (Chulilla *et al*., 2009). Iron deficiency is often suspected based on specific abnormalities seen in the CBC (Weiss, 2010). Iron is important in the production of red blood cells, so iron deficiency will eventually cause a non-regenerative anemia (Michel, 2006). Various tests of iron stores can be performed if iron deficiency is suspected.

There are mainly two types of treatment protocol existing for anemic condition of any type of anemia. These are treatment either with nutritional supplements or with blood transfusion; in few cases treatment with combined protocols is also common (Miller *et al*., 2009). The choice of treatment is mainly determined by the severity of anermia and hemato-biochemical parameter of the anemic patient (Naigamwalla *et al*., 2012). Blood with a PCV of 10 % will have lost two-thirds of its circulating red cells. In mild type of anemia when PCV remains within 20-22%, hematinic drugs are the main choice of treatment for any species. In case of moderate anemia (PCV less than 20%) and severe anemia (PCV less than 15%), goats lost two-thirds of their circulating red

cells, causing death (Muir, 2007). In this condition, blood transfusion is the immediate treatment option to save the life of these animals.

The practice of blood transfusion from one individual to another has become an important tool in veterinary critical care and emergency medicine. Over the past era, the use of blood products in treating critically ill anemic animals has radically improved (Weingart *et al*., 2004; Saritha *et al*., 2016). Moreover, it is important because it can effect on the patient's capability to overcome the disease and other disabilities (Mamak and Aytekin, 2012). Blood transfusion objects to replace the missing component of blood to increase oxygen carrying capacity (Kisielewicz and Self, 2014). The most common indications of blood transfusion include life threatening anemia from acute hemorrhage or surgical blood loss, hemolysis from drugs or toxin, immune mediated diseases, sever non-generative condition and neonatal isoerytholysis (McDevitt *et al*. 2011). Oxygen in blood is carried by hemoglobin (Hb) and this function is disrupted in anemic patient leading to inadequate tissue perfusion. Most of the clinically ill animals die due to severe anemia (Tufani *et al*., 2009). Considering this life threatening condition, blood transfusion has a great role to increase the oxygen carrying capacity of blood and also inadequate delivery of oxygen to tissue's (tissue hypoxia) is prevented or treated (Callan, 2010).

In emergency condition with severe anemia, the choice of blood transfusion should be dependent on the prognosis of the underlying condition of anemia and the availability of a suitable donor (Ermilio and Smith, 2011). Whole blood is indicated when several blood components are obligatory or when the patient has acutely lost more than 50% of its total blood volume, in order to increase oncotic pressure and reestablish tissue oxygenation (Lanevschi and Wardrop, 2001). Cross- matching of small ruminant's blood before a single transfusion is not very necessary because of the minimal level of agglutinating antibody present in ruminant serum (Sousa *et al*., 2014). However, it becomes necessary when multiple transfusions are to be performed to avoid transfusion reaction (Kumar, 2017).

Transfusion reactions are defined as any adverse reaction after receiving total blood or any blood component. However, some reports stated that transfusion reaction in ruminants receiving a single blood transfusion is uncommon (Hunt and Moore, 1990).

The most common signs of transfusion reactions are fever, tachycardia or bradycardia, hypotension, dyspnea, cyanosis, excessive salivation, tearing, urination, defecation, vomiting, collapse, opisthotonos, cardiac arrest, hemoglobinemia, and hemoglobinuria (Mamak and Aytekin, 2012). These signs are mainly resulted from volume overload, undesirable reaction of blood, citrate toxicity, faulty administration and any type of infection during collection or storage of blood or blood products.

Blood transfusion is relatively simple to perform with a low cost and can save the life. There are several studies have been carried out on transfusion of blood in dogs and cats all over the world (Roux *et al*.2008). However, limited numbers of studies have been conducted on ruminant blood transfusion. As far as author's knowledge, there were few studies conducted on blood and plasma transfusion of calves in Bangladesh (Sufiun, 1999; Alam *et al*, 2000 and Rahman *et al*., 2000). However, no study was published on blood transfusion in goats. It will be economically justifiable research for goat population in Bangladesh.

Generally only hematinic drugs are the choice of treatment for any types of anemia in goat in the field practices in Bangladesh that cannot save life in many cases. Therefore, the result of this study will be useful for the successful blood transfusion in the field. This study is planned to know the principles and indication for blood transfusion in goats.

Therefore, it is very important and the need of time to find out some alternative and effective treatment regimens for the clinical management of anemia in goats. This is why, the present research work was undertaken to establish a suitable convenient and economically feasible protocol of blood transfusion for the clinical management of anemia in goats. The research was performed with the following objectives-

1. To investigate the effects of blood transfusion and administration of hematinic drugs for the clinical management of anemia in goats.
2. To observe post-treatment changes in the hematological and biochemical parameters in the anemic goats.
3. To know the adverse effects of blood transfusion (if any) in goats.

CHAPTER-II

REVIEW OF LITERATURE

Review of Literature

2.1 Caprine hematology:

Hematological status of goats varies according to age, breed, sex and health status in different environment and climate. Bone marrow is the prinicipal organ of hematopoiesis in goat. Spleen is another hematopoietic organ is located in the left craniodorsal abdomen between the diaphragm and the dorsal sac of the rumen. Goat also possesses hemal node system containing lymphoid tissue that also participates in blood storage by hemo-concentration.

2.1.1 Bone marrow:

Bone marrow is a soft gelatin like tissue found in the central cavities of long bones and some short bones that contains stem cells. There are two types of bone marrow- red bone marrow (which is also known as myeloid tissue) and yellow bone marrow (fatty tissue). Red blood cells, platelets and most white blood cells arise in the red bone marrow whilst some white blood cells develop in the yellow marrow.

The two types of stem cell found in bone marrow are:

Hematopoietic cells: Produce all the blood cell types in the body with over 200 billion new red blood cells produced every day in healthy tissue.

Stromal cells: These produce fat, cartilage and bone.

2.1.2 Haematopoiesis:

Hematopoiesis is the production of blood which system is widely distributed throughout the body.

Embryonic haematopoiesis-

Mesenchyme the embryonic connective tissue constitutes the ontogenetic analogue of blood cells that are first formed in the numerous blood islands of yolk sac. These mesoblastic elements differentiate in two directions. The peripheral cells from the endothelial lining of the first blood vessels, whereas those that are centrally located become primitive blood cells with megaloblasticx morphologic features.

Postnatal haematopoiesis-

The transition from embryonic life to postnatal life is not marked by any sudden change. A population of stem cells supports production of megakaryocytes,

granulocytes, monocytes and erythrocytes. These cells have properties of self-renewal, proliferation and differentiation. In the adult, erythropoiesis is confirmed to marrow spaces, principally in axial skeleton and ends of long bones. Where there is increased demand for cell production, such as in blood loss or hemolytic disease erythropoiesis expands to spleen, liver and lymphnodes (Car, 2010).

In the bone marrow, erythropoiesis goes on continuously and corpuscles are poured into the blood stream at the rate to balance the destruction of red cells. Therefore, the total number of blood cells does not fluctuate greatly. The newly formed no-motile erythrocytes enter the capillary by diapedesis.

Erythropoietin, a glycoprotein hormone stimulates red cell production which appears to be increased in the body fluids of animals subjected to various forms of hypoxia. Other hormones like androgens potentiate the action of erythropoietin. On the other hand, estrogens have an inhibitory effect on erythropoiesis. Thyroid, pituitary and adrenocortical hormones alter tissue demands for oxygen, thereby changing the requirements for erythropoiesis (Oliver, 2010).

2.1.3 Blood composition:

The blood is composed of two types of substances- cellular substances (42- 45%) and liquid intercellular substances (plasma) (55-58%).

a) Cellular substances-
   Erythrocytes
   Leukocytes
   Platelets
b) Liquid intercellular substances-
   - Liquid (91-92%)
   - Solids (8-9%) – These are mainly comprised of inorganic constituents (0.9% sodium, potassium, calcium, magnesium, phosphorus, iron, copper etc.) and organic constituents.
   - Proteins- 7.5% serum albumin, serum globulin, fibrinogen, prothrombin etc.
   - Non-protein nitrogenous substances(NPN)- Urea, uric acid and xanthine, hypoxanthine, creatine, creatinine, amino acids etc.
   - Fats- Neutral fat, phospholipid, cholesterol, cholesterides etc.

- Carbohydrates-Glucose, sucrose etc.
- Other substances- internal secretions,antibodies and various enzymes (amylases, proteases, lipases, phosphatases etc.)
- Colouring matters- Yellow colours of plasma is due to small amount of
- bilirubin, carotene and xanthophyllin

Table-1: Normal hematology of common blood parameters in goat

(Shaikat et al., 2013)

Parameters	Normal range
Total erythrocyte count (million/cumm)	8.02-17.05
Hemoglobin (g/dl)	3.6-6.6
Packed Cell Volume (%)	22-34
WBC (thousand/cumm)	2.5-14.2
Erythrocyte sedimentation rate (mm/1st hour)	0

2.2 Anemia:

Anemia is a condition caused by a shortage of hemoglobin or red blood cells when it is clinically suggested by pale or white mucous membrane, weakness, head down condition, exercise intolerance, tachypnea, tachycardia and in extreme case collapse. Signs of anemia is also related with causes of anemia but frequently accompanied by the signs of hypoproteinemia, particularly intermandibular edema, ascites, weakness and weight loss (Miller *et al*., 2009). Anemia is common and most important clinical presentation in goats and in severe case the only treatment is blood transfusion.

Causes of anemia:

(i) Hemolytic anemia- Established causes of hemolytic anemia in goats are hemoparasitic diseases like anaplasmosis, babesiosis, theileriasis and eperythrozoonosis; nutritional disorders like copper toxicity, consumption of regional poisonous plants and infectious causes leptospirosis, infection due to *Clostridium hemolyticum* and *Clostridium perfringens* type A.

(ii) Blood loss anemia- Clinically it is the most important clinical condition in goats where anemia found due to blood loss and it is associated with parasitism. Important causes of blood loss anemia include infestation by Haemonchus spp.,

liver flukes, and external parasites including sucking lice, tick and fleas. Sometimes accidental causes, dog bite and any trauma may also cause blood loss anemia.

(iii) Causes of anemia due to impaired erythropoiesis- Anemia of this type occur due to nutritional causes including cobalt, copper and iron deficiencies and also due to chronic infection like paratuberculosis. Iron deficiency is assosciated with prolonged feeding of doe's milk to kids without supplementation or access to forage.

2.2.1Treatment of anemia:

Treatment of anemia may vary depending on the condition present in anemic patient and the cause of anemia. If the anemia is not so severe, maintaining an effective internal and external parasite program and providing a free choice, high quality loose mineral made expressly for goats (including copper, iron & cobalt) should be the first step on the way to prevention.

For treatment, firstly the cause of the problem must be elicited. After checking for parasites it is important to treat the cause and then provide supplementary care to assist the goat in recovering. The use of injectable iron may be necessary in anemic cases but dosage must be carefully monitored since iron can be toxic and overdosing can suppress vitamin E (Gross *et al*., 2000).

If a goat is severely anemic, the only way to boost the packed cell counts is through blood transfusion. It is a quick boost to the red blood cells to support the body to heal and make more red blood cells itself.

2.3 Blood transfusion:

Blood transfusion is the process of receiving blood products (whole blood, red blood cells, white blood cells, plasma, clotting factors and platelets) into one's circulation intravenously which is an effective method of fluid replacement but also a potentially hazardous form of treatment. It is the lifesaving therapy for both human and animals when it is required.

2.3.1 History:

The first report of a successful blood transfusion in animals was by Richard Lower in 1665 where the blood was withdrawn from one dog and replaced with blood from

another dog (Lower 1665). Despite early experiments, small animal blood transfusions have only become common over the last 30– 60 years (Davidow 2013).

2.3.2 Indications of blood transfusion:

In ruminants, generally whole blood transfusions are applied to patients that have acute blood loss caused by trauma, surgery, or some other conditions like splenic rupture or uterine artery hemorrhage. The transfusion recovers blood volume and oxygen-carrying capacity in cases of blood loss. Chronic anemia may be a more common problem in ruminants. Gastrointestinal parasites particularly *Haemonchus* and ectoparasites (e.g. *Haematopinus* spp. and *Linognathus* spp.) cause chronic blood loss anemia and iron-deficiency anemia. These can affect neonates too (McClure, 1997)

General:

i. Life threatening anemia- Acute hemorrhage, Surgical blood loss, Hemolysis from drugs or toxins, Immune mediated disease, severe regenerative diseases, Neonatal isoerytholysis.
ii. Acute hemorrhage- Trauma, Complication after cesarean section, Uterine prolapse, umbilical vessel damage in new borne calf, melena from abomasal ulcer.
iii. Parasitic diseases- Babesiosis Anaplasmosis, Theileriosis, Gastrointestinal parasitic diseases (eg. *Haemonchus* sp.), Ectoparasite (*Haematopinus* sp., *Linognathus* sp.)

Specific:

i. Whole blood- Severe hemorrhage, Hemolysis, Hypovolemia, Thrombocytopenia, Clotting factor deficiency, Hypoprotenemia
ii. Fresh frozen plasma- Single or multiple clotting factor deficiency, Vit k deficiency or antagonism, surgical bleeding, Hypoalbumenemia and coagulopathies due to liver disease, Von willebrand disease.
iii. Platelet- Thrombocytopenia, control associated hemorrhage, hemorrhagic diathesis, anticancer therapy
iv. Granulocyte- Supportive therapy, after high dose chemotherapy, Neutrophil dsfunction, myelosuppression, neonatal sepsis.

2.3.3 Contraindication:

Anoxic animals with maniacal behavior may be life threatening during transfusion process. The presence of exogenous blood antigens may trigger further hemolysis. So, special care must have to take before deciding any patient to transfuse. Anaphylaxis is an important contraindication for further blood transfusion.

2.3.4 Blood types:

Blood group types vary from species to species and early concepts suggested that this blood grouping is confined to the surface antigens of erythrocytes.

There are eleven blood groups in cattle (Mamak and Aytekin, 2012). The greatest clinical relevance is in groups B and J. The B group is extremely complex, thus closely matched transfusions are very difficult. Newborn calves do not have the J antigen. During the first six months of life they generally acquire it. Cows can be sensitized to erythrocyte antigens by vaccinations of blood origin like some anaplasmosis and babesiosis vaccines. As a result of this neonatal isoerythrolysis in subsequent calves occur (Giger, 2000; Brown *et al*., 2006).

There are seven blood groups in sheep, identified as R-O, A, B, C, D, M and X. The B group in these animals is resembled to the B group in cattle and the R group is resembled to the J group in cattle (Mequanent *et al*., 2018). R-O group are soluble substances and naturally occurring anti R antibodies may be found in R negative sheep. In the goat, five blood groups are identified as B, C, M, R-O and X which resemble to those of sheep (Brown *et al*., 2006). The M system in sheep is associated with variation in intracellular RBC potassium concentration, with animals homozygous for the Ma allele having greater intracellular potassium levels. Though high potassium and low potassium red cell types have also been recorded in goats, but no clear association with the M blood has been found, yet several attempts have been performed.

In ruminants, the first blood transfusion should usually be safe, regardless of the donor (Mamak and Aytekin, 2012). J negative and R negative donor is ideal. Because agglutination reactions do not develop, routine cross-matching is not useful in ruminants. First transfusions are usually safe to apply without a blood cross-match but cross-

matching is recommended when more than 48-72 hours have passed away since the first blood transfusion.

Table-2: Blood type of different domestic ruminants (Mamak and Aytekin, 2012)

Species	Number of blood type	Iso-antibodies (antigenic blood types)
Cattle	11	Anti J
Sheep	7	Anti R
Goat	5	Anti R
Pig	16	Anti A
Ilama and alpaca	6	-

2.3.5 Transmissible diseases through blood transfusion in ruminants:

Different types of diseases can be transmitted donor to recipient through blood transfusion if proper precautions don't be maintained. So, a proper history of the donor with observation of current health status is very important prior to transfusion. It is also noted that sometimes apparently healthy animals may also be carrier of different transmissible infectious organism. To avoid this unacceptable situation after blood transfusion, proper blood examination of donor especially for presence of any blood parasite or not is necessary.

Most commonly anaplasmosis, babesiosis, theileriasis, leucosis viral hepatitis, brucellosis, filariasis can be transmitted through blood

Infectious agent not only spread from donor blood but also spread to recipient from different contaminating sources. Blood can be contaminated at the time of collection (if sterile pack is not maintained), preparation of blood products and administration method. The commonly isolated organisms are environmental contaminants and normal skin flora. It is also important to mention that certain saprophytic bacilli (eg. *Pseudomonas sp*) multiply at temperature of 4-8^{o} C, resist the normal bacteriostatic effect of blood and utilize citrate as a source of carbon.

2.3.6 Estimation of blood for transfusion:

Domestic animals have blood volumes of 7%–9% of their body weight whereas cats have a slightly lower volume of 6.5%. And goats are considered as large spleened

domestic species whereas a health goat can accommodate a blood loss up to 25% of the red cell mass acutely (Mamak and Ayetkin, 2012).

Generally, whole blood can be administered at a dose of 10–15 ml/kg which will only increase the packed cell volume of the recipient by 3–4%. For hemorrhagic shock, at least half of the estimated blood loss should be replaced by whole blood. Monitoring of the transfusion is important and the whole blood transfusion should be started at a slow rate (0.1 ml/kg/hour) with vital signs evaluated every 5 minutes.

Calculation of the amount of blood for transfusion (Mequanent *et al*., 2018):

Volume of donor blood required = bodyweight of recipient (kg) x 70 x ((desired PCV - PCV of recipient)/PCV of donor)

But in acute blood loss cases, PCV is usually impractical for estimation of volume to be transfused because it does not exactly indicate blood loss.

2.3.7 Cross-matching test:

In transfusion medicine, cross-matching (part of series of step in blood compatibility tests) is testing before a blood transfusion to determine if the donor's blood is compatible with the blood of an intended recipient. The purpose of the cross-match is to detect the presence of antibodies in the recipient against the red blood cells of the donor. These antibodies attach to the red blood cells of the donor after transfusion. An incompatible transfusion can result in a severe hemolytic anemia and even death.

But a cross-match is not absolutely required on the first blood transfusion. Once a blood transfusion has been administered, a cross-match should be performed prior to any subsequent transfusions to detect antibodies that may have been produced against a different red blood cell antigen. But in cats, a cross-match should be performed on the first blood transfusion, because cats have naturally occurring antibody against red blood cell antigens.

In goat and sheep, it is advised that R positive blood not be used for transfusion to avoid early donor RBC destruction by isoantibodies. Cross matching of goat and sheep blood before single transfusion is not usually necessary. But it is advisable to do cross matching in goat transfusion because naturally occurring antibodies can be present in goats. There are two methods namely major and minor cross match test for determining compatibility of donor and recipient’s blood. This major and minor cross-matching do

not indicate types of blood group, these only help to prevent acute hemolytic reaction, to provide optimal lifetime of the transfused RBCs and to prevent neonatal iso-erythrolysis.

Major cross match:

A major cross match includes putting patient's serum into donor's cell and result of this test determines the presence of agglutinating and/or hemolytic antibodies in the patient against the donor antigens.

Minor cross match:

A minor cross match includes putting donor serum into patient erythrocyte that reveals antibodies in donor serum against recipient cells. Cross-matching can also be done by different cross-matching kits which are specific for different species.

Procedure:

The major cross-match consists of combining equal volumes (0.1 ml) of the donor RBC suspension and recipient plasma. The control tube contains recipient RBCs and recipient plasma. The samples are incubated, centrifuged, and evaluated for hemolysis or agglutination. Hemolysis is evaluated by comparing the color of the supernatant in the test sample with that of the control sample. Each sample is then gently shaken until all cells in the "button" at the bottom of the tube have returned to suspension. Again, the degree of cell clumping of the test sample is compared with that of the control sample. The test is negative, or compatible, when the plasma is clear and the RBCs are readily suspended. A positive, or incompatible, test can have hemolysis or hemagglutination or both. All tests judged macroscopically to be negative for hemagglutination should be confirmed microscopically at low power. Some newer cross-matching systems that use a gel technique are becoming available. This is particularly important in horses, because their RBCs tend to form rouleaux.

The minor cross-match is the reverse of the major cross-match, ie, recipient cells are combined with donor plasma. The minor crossmatch is important only in species such as cats with clinically significant naturally occurring isoantibodies or if the donor has been previously transfused or, in horses, those with previous pregnancies.

Table-3: Interpretation of blood cross-matching

Cross-match	Result	Interpretation
Major	Compatible	The transfusion can be given. Note that the crossmatch will not detect very low titer antibodies.
	Agglutinins and/or hemolysins	The crossmatch is incompatible and the donor should not be used
Minor	Compatible	The transfusion can be given
	Agglutinins and/or hemolysins	Preferably, washed or packed red cells from the donor should be administered. In reality, dilution of the transfusion in the recipient usually eliminates any likelihood of antibodies from the donor affecting the recipient's red cells.
Autocontrol	Agglutinins and/or hemolysins	This reaction is usually seen in animals with immune-mediated hemolytic anemia. In these, interpretation of incompatible crossmatches is very difficult and a compatible donor may not be found.

2.3.8 Routes of administration:

There are several routes for administering blood and blood products in animal body. **Intravenous route** is the most common and most effective route because the infused RBCs and plasma are available to the general circulation immediately.

The **intraosseous route** is ideal only when vascular access is difficult or unsuccessful and is most commonly used in neonates. Common sites for intraosseous transfusion are the trochanteric fossa of the femur, the wing of the ilium, and the shaft of the humerus. With this route, the infused cells and proteins are available to the general circulation within minutes of delivery, but there is a risk of osteomyelitis.

The **intraperitoneal route** is painful and should not be used unless absolutely necessary. With this route, the infused RBCs are completely absorbed, but the absorption is delayed. At 24 hours, only about 50% of the infused RBCs and proteins will have reached the general circulation.

2.3.9 Donor animals:

Criteria of donor animals:

a. Donor should be healthy, young and adults with good temperament.
b. They should not be pregnant and with a history of never have a previous transfusion.
c. They should be free of infections that might be transferred through blood transfusion
d. They should be free from bovine leucosis virus, anaplasmosis, brucellosis, theileriasis, tuberculosis, salmonellosis and other blood borne parasitic disease indigenous in the area.
e. They should contain the normal hemato-biochemical parameter.

Blood test before collection:

For the safety of both the blood donor and recipient, the health of a donor is evaluated prior to enrollment as a donor and a complete medical history, physical examination and laboratory evaluation including a hemogram, serum biochemistry profile and infectious disease screening tests should be performed. In addition, measurement of packed cell volume and hemoglobin concentration should be performed before each transfusion. All parameters should be in normal range.

2.3.10 Collection of blood:

Blood collection materials:

Commercial 450 ml collection bags manufactured for human blood banking are used for canine donations. These contain an anticoagulant - preservative solution (APS) and a sterile collection line with a 16 gauge thin walled needle attached to the bag. Vacuum bottle can be used containing anticoagulant preservative solution. But the chief disadvantage is its collection system and more possibility of contamination. Blood may also be collected into syringes for purpose of blood transfusion. It is mainly applicable for small amount blood transfusion. Anticoagulant is placed in a large plastic syringe (60 ml) and an appropriate quantity of blood is drawn from the donor's vein.

Common anticoagulants- preservative solution:

Commonly used anticoagulants are oxalates, trisodium citrate, dipotassium or disodium salt of ethylene-diamine-tetra-acetic acid (EDTA) and heparin. Oxlates have been largely replaced by EDTA due to its toxic nature.

Table- 4: Common anticoagulant-preservative with amount

Anticoagulant-preservative	Amount
EDTA	1-2 mg/ml blood
Heparin	0.1ml/ 5ml of blood
CPD	0.1ml/1 ml of blood

Collection priniciples:

Blood can be collected as whole blood either by closed or open system (Divers, 2005). This collected blood is then separated into its components by centrifugation.

Closed System

A closed system allows for the collection, processing, and storage of blood and blood components without exposing them to the environment; therefore, the risk of bacterial contamination is minimized. For this procedure, single-collection bags are available that contain an anticoagulant solution plus integral tubing with a 16-gauge needle already attached.

Open system

In an open system of collection (e.g., drawing blood with a syringe), blood and blood components are exposed to the environment, a disadvantage compared with the closed system

Closed system is better in that sense that open system has one or more additional sites of entry and possible bacterial contamination such as occurs when preparing for blood collection into syringes, acid- citrate - dextrose (ACD) bottles, or bags to which anticoagulant is added after manufacture. Another major mentioning point is that components prepared from blood collected into an open system are not intended for storage. If an open collection system is used, the American Association of Blood Banks and Council of Europe advise that RBC products (stored at 1 – 6° C) should be used within 24 hours and platelet products (stored at 20 – 24° C) should be used within

4 hours. The shelf - life of plasma from an open system is unaffected if it is frozen within 8 hours.

2.3.11 Adverse transfusion reaction:

Adverse reactions are two types immunologic and non-immunologic. The mechanisms of non-immunologic reactions are various. According to the specific reaction the type and severity of clinical signs vary (Chiaramonte, 2004). Adverse reaction occurs in 2 types. First one is immediate reaction and following transfusion it occurs within 1 to 2 h. Second is delayed reaction and it may begin within days, months, or years later. Adverse reaction varies from mild (fever) to severe (death). Transfusion reactions can be acute or delayed.

i) Acute transfusion reaction:

Immunologic -Acute hemolytic transfusion reaction
-Neonatal isoerytholysis
-Type I hypersensitivity
-Febrile non hemolytic transfusion reaction
-Transfusion related acute lung injury

Non-immunologic -Volume overload
-Citrate toxicity
-Hypothermia
-Bacterial contamination

ii) Delayed Transfusion reaction:

Immunologic- Delayed hemolytic reaction
Post transfusion purpura

Non-immunologic- Infectious disease transmission

Clinical signs are restlessness, vocalisation, tachypnoea, bradycardia, tachycardia, hypotension and hypertension. Pyrexia is seen frequently as a result of reactions to donor leukocytes, platelets and plasma proteins. As a result of binding by citrate, there is potential for hypocalcaemia when administering large volumes of blood products. Vomiting or diarrhea can be seen after plasma administration. Urticaria may be found and hypervolemia can result in pulmonary edema (Tocci and Ewing, 2009).

2.3.12 Management of transfusion reaction:

(a) Anaphylactic shock:

- Major clinical sign- Collapse, respiratory and/or cardiac arrest.
- Treatment- Stop the transfusion, administer epinephrine and copticosteroid, commence of CPCR

(b) Type 1 hypersensitivity:

- Major clinical sign- Tachypnea, fever, cardiac arrhythmia, vomiting, urticaria, pruritus, angioedema, erythema.
- Treatment- Stop the transfusion, administer corticosteroids and/or antihistamines, restart the transfusion at a slower rate.

(c) Acute hemolysis:

- Major clinical sign- Tachypnea, fever, hemoglobinuria, collapse, shock.
- Treatment: Stop the transfusion, administer corticosteroids and IV fluids with or without vasopressor to maintain arterial blood pressure.

(d) Microbial infection:

- Major clinical sign- Tachypnea, tachycardia, fever, vomiting, collapse.
- Treatment- Stop the transfusion and remove all contaminated lines and catheters, collect donor blood sample and recipient blood and urine samples for culture, administer systemic antibiotics and IV fluids to maintain blood pressure.

(e) Citrate overdose:

- Major clinical sign- Hypocalcemia, tremors, fever, cardiac arrhythmia,vomiting, seizures.
- Treatment- Administer 10% calcium gluconate (1 ml/kg slow IV) and monitor the ECG.

(f) Hypothermia:

- Major clinical sign- Depression, shivering, low temperature
- Treatment- Stop the transfusion, administer warm blood products and begin active external warming of the patient.

(g) Circulatory overload

- Major clinical sign- Tachypnea, normal to low heart rate, pulmonary edema, Increased central venous pressure

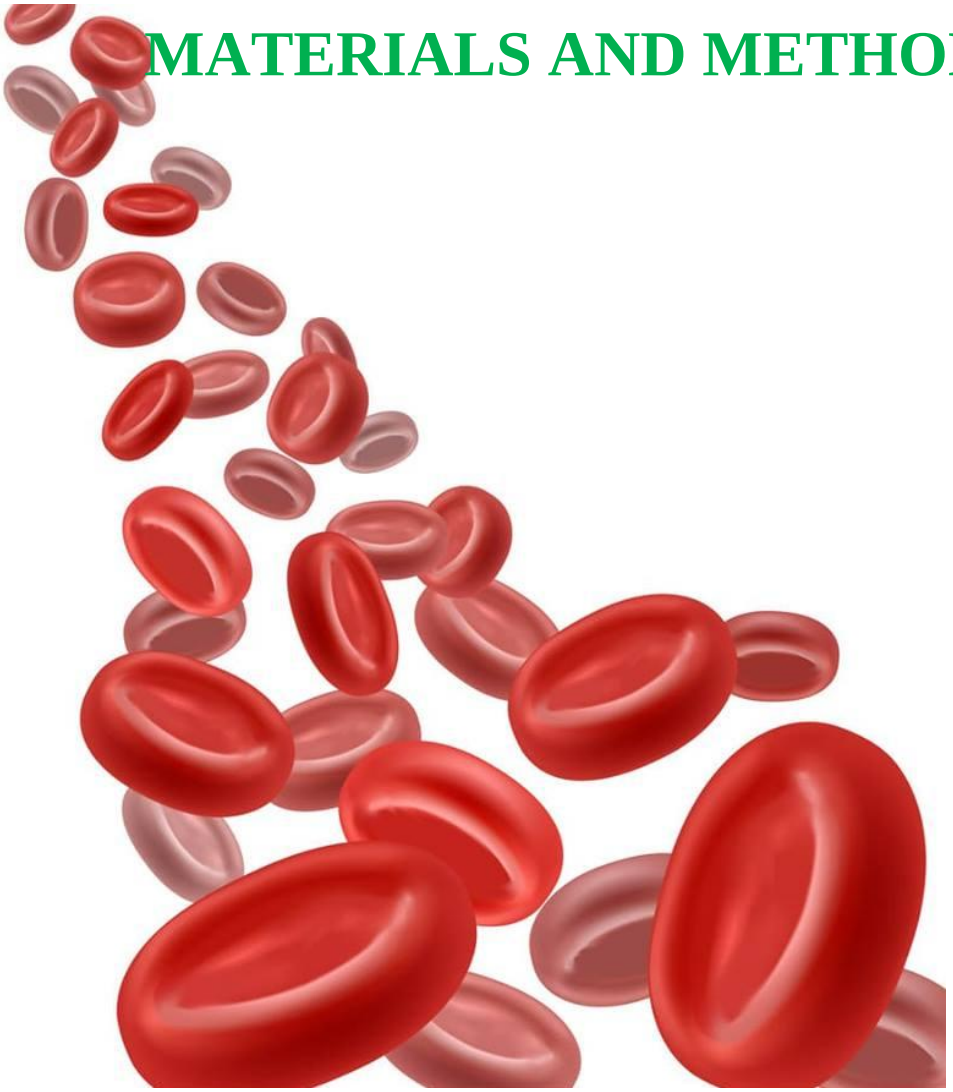
- Treatment- Stop the transfusion, administer diuretics with or without vasodilators, restart the transfusion at a lower rate,if appropriate,or use a different blood product (e.g.,pRBCs venous pressure rather than whole blood).

(h) Hyperkalemia:

- Major clinical sign- Bradycardia, cardiac arrhythmia, diuresis
- Treatment- Stop the transfusion,administer 0.9% NaCl IV for diuresis.

CHAPTER-III

MATERIALS AND METHODS



Materials and Methods

3.1 Study area:

The study was conducted at Shahidul Alam Quaderi teaching veterinary hospital (SAQTVH) of Chittagong Veterinary and Animal Sciences University (CVSAU), Chittagong, Bangladesh during the period of January 2017 to September 2017. Anemic patients that came from different parts of Chittagong district to SAQTVH were selected as population for this study.

3.2 Design of the study:

A review of clinical cases of anemia in goats that registered in the clinical case registration card of SAQTVH from July 2016 to December 2016 was studied before applying blood or any hematinic drug to patients.

Goats presented with the history of weakness, anorexia, pale or white mucus membrane and lower PCV and hemoglobin from normal parameter after blood examination were selected for this study. Total 23 goats were divided into two groups depending on the treatment approach for anemia.

Group I : **Blood transfusion group (13)-**

Among the anemic clinical patients (goat) of SAQTVH the patients which contain the PCV less than 18% were selected for blood transfusion from same species and they are followed up for result.

Group II: **Hematinic group (10)-**

This group was mainly treated with hematinic drug without any blood transfusion whether PCV were also less than 18%.

3.3 Requirements:

General:

- Syringe (sterilized syringe)
- Blood bag (JMS, 450 ml blood bag with 63 ml anticoagulant CPDA)
- Slide
- Donor
- Recipient
- Hematinic drug (eg.: Inj. Hemovit® Renata pharmaceutical limited))

- Normal saline (eg. Inj. Normasol, Libra pharmaceuticals limited)
- IV infusion set (JMI, Sterilized by ethylene oxide)

For hemato-biochemical test:

- Microscope (Optica, biological microscope)
- Cover slip
- Hemocytometer
- Shali's hemometer
- Wintrobe tube

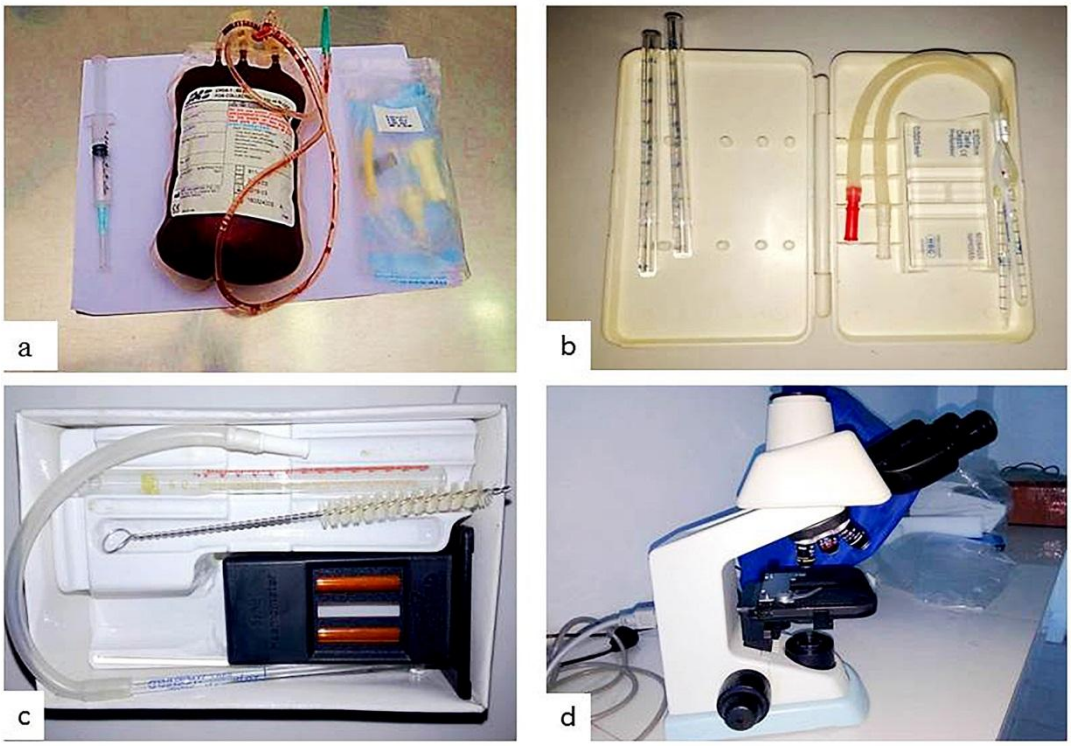


Figure-1: (a) Blood bag with CPDA-1, IV insfusion set, Syringe; (b) Haemocytometer with wintrobe tube (c) Sahli's hemometer (d) Microscope

3.4 Group I- Blood transfusion group:

2.4.1 Donor selection:

Total 13 goats (eight male and five female) were used to collect blood for transfusion in this study. Every donor was healthy, free from ecto-parasites and blood parasite, age ranging from 1.5 to 2.5 years. The donors were not transfused previously and routinely dewormed. The female donors were not pregnant. Donors were always chosen healthy blood collection.

3.4.2 Recipient:

Anemic patients were considered for blood transfusion. Thirteen recipients that were admitted to SAQ teaching veterinary hospital for the treatment of anorexia and severe weakness containing PCV below 18% were considered for blood transfusion. Their ages ranged from 1 to 2 years. Proper clinical examination was performed to find out the presence of any ecto and endo parasite, or other diseases.

3.4.3 Pre-transfusion examination:

Collection of blood:

Blood samples of both donor and recipient were collected for various hematological examinations before collection and transfusion of blood. Seven ml of blood was collected from jugular vein of both donor and recipient for every transfusion. This 7 ml was transferred into 3 vacutainers. Two and half mililitre (ml) was transferred into vacutainer containing anticoagulant EDTA, 3 ml was transferred into another vacutainer containing no anticoagulant and rest 1.5 ml was transferred into another vacutainer containing EDTA.

Hematological examination:

Vacutainer with EDTA containing 2.5 ml blood of both donors and recipients were examined to determine total erythrocyte count (TEC), total leukocyte count (TLC), hemoglobin (Hb), packed cell volume (PCV) and Erythrocyte sedimentation rate (ESR).

Blood parasite examination:

Vacutainer (with EDTA) containing 1.5 ml blood of donors and recipients were examined to identify the presence of any blood parasite. Donors which showed any positive result in blood parasitic examination were considered non-eligible donors.

Serum protein determination:

Vacutainer without anticoagulant containing 3 ml blood were transferred to laboratory for preparing serum to determine total protein.

Fecal examination:

Fecal examination was performed for both donor and recipient to identify the presence of any type of endo-parasite. If any donor showed positive result for any parasite in fecal test, were rejected for transfusion process.

Compatibility test between donor and recipient blood:

Before transfusion, one cross matching between donors and recipients was performed according to the protocol of Mamak and Aytekin (2012). No compatibility test was done for rest 12 cases.

3.4.4 Blood transfusion technique:

Preparation of blood bag:

450 ml blood bags containing 63 ml CPDA (Citrate phosphate dextrose adenine) were used for transfusion of blood in goat.

Technique of blood collection:

Thirteen goats were used as single time donor for blood collection. The donors were restrained in standing condition and jugular vein areas were preferred aseptically to avoid any type of contamination. Fixed needle given with blood transfusion bag was used to puncture the jugular vein and a free flow of blood was obtained. The blood bag was gently agitated during collection of blood to ensure proper mixture with the anticoagulant. After collecting blood, the needle was withdrawn and the punctured site was pressed with alcohol soaked cotton. Then the donor was supplemented with iron containing drug intramuscularly and normal saline with amino acid preparation mixture intravenously.

Transfusion of blood to the recipient:

The recipients were controlled according to their position. Recumbent animals were controlled in recumbent condition and standing animals in standing position. The left jugular furrow area was aseptically prepared for transfusion of blood. The collected blood bag and normal saline bag were placed in saline stand nearby the patient. For administering blood to the recipient through intravenously, initially 0.3 ml/ kg was administered for first 5 minutes (min). After finding no sign of transfusion reaction, 30 drops/ min were administered for next 10 minutes. Then 40-60 drops/min were continued for rest of the period (Figure-2). Blood was administered at the dose rate of 10-12 ml/kg body weight.

If any recipient showed restlessness, blood transfusion was stopped for few times and normal saline was given instead of blood transfusion. When restlessness was controlled, blood was transfused again to the patient.

Figure-2: Fresh blood transfusion in a severely anaemic goat

3.4.5 Monitoring of recipient and post-transfusion examination:

All recipients were monitored for any type of blood transfusion reaction. Respiratory rate, heart rate and rectal temperature were recorded during the period of blood transfusion. Hemato-biochemical tests for recipient's blood were performed after transfusion at day-3, 6, 9 and 12.

3.5 Group II-Hematinic group:

Ten anemic patients containing PCV less than 18% were treated with hematinic drugs. Same hemato-biochemicl tests were performed for group II. After treatment, all patients were observed for physical improvement. Hemato-biochemical tests were also performed according to group I.

3.6 Statistical analysis:

The data processing included descriptive statistics of individual data regarding the breed, transfused doses and the hematological values. Hematological data obtained before and after transfusion were statistically analyzed using one-way ANOVA using STATA 2013, with $p < 0.05$ being statistically significant.

CHAPTER-IV

RESULTS

Results

4.1 Effect of blood transfusion in recipient:

Total erythrocyte count:

The mean value of TEC in recipient before transfusion was 3.78 ± 0.38. After 3 days (fig. 3-c) of transfusion the mean value was increased insignificantly ($p<0.05$) whether highest valve was statistically significant found at 12^{th} days (fig. 3-f) (mean value was 7.29 ± 1.33) of blood transfusion (table 5).

Packed cell volume and Hemoglobin:

The mean value of PCV and Hb before transfusion were 11.46 ± 2.22 and 3.98 ± 0.62, which were increased significantly ($p<0.05$) at 6^{th}, 9^{th} and 12^{th} day after blood transfusion with full recovery during follow up. On 12^{th} day after transfusion mean value of PCV was in normal range (table 5).

Erythrocyte sedimentation rate:

The mean value of ESR declined significantly ($p<0.01$) from 6^{th} day of post transfusion. The mean value of ESR in recipient before transfusion was 1.91 ± 0.49, which was changed significantly ($p<0.01$) with the value 0.29 ± 0.20 at 12^{th} day of experiment (table 5).

Total protein:

Before transfusion the mean value of TP was 2.04 ± 0.14, which was half from normal range. After blood transfusion, this range raised to normal limit at 12^{th} day of post transfusion. In this study, the highest value was found as 3.88 ± 0.27 at 12^{th} day of post-transfusion. Increase of TP values in recipient were statistically significant ($p<0.05$).

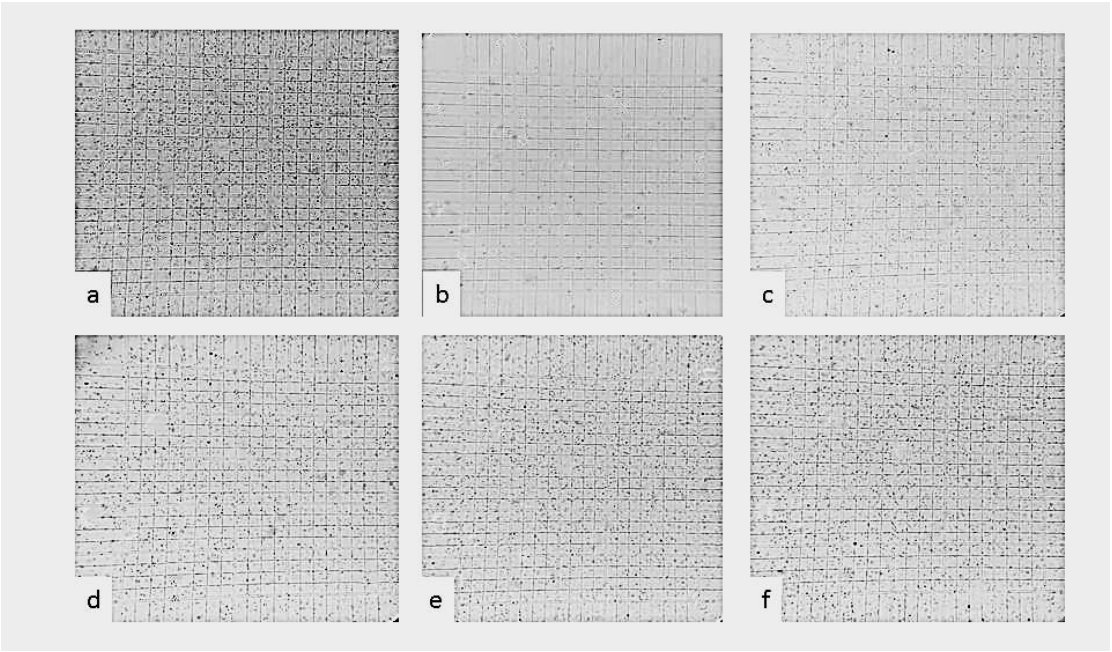


Figure-3: Advancement of concentration of erythrocytes at TEC count: (a) Total erythrocyte count of donor was within normal range; (b) Total erythrocyte count of recipient before transfusion was lower than normal level which is noticed by the erythrocyte arrangement in each small cell (c) Total erythrocyte count of recipient at 3^{rd} day, when there is found insignificant increase of erythrocytes (d) Total erythrocyte count of recipient at 6^{th} day, when significant change of erythrocyte was found (e) More number of erythrocyte was observed on total erythrocyte count of recipient at 9^{th} day (f) Total erythrocyte count of recipient at 12^{th} day, when erythrocytes found around normal level.

4.2 Effect of hematinic drug in severely anemic patient:

After hemato-biochemical parameter examination, ten patients containing less than 12% PCV were under the treatment of hematinic drug and different vitamin preparation during this study. In hematinic group, the mean values of PCV and Hb before treatment were as 9.60 ± 0.69 and 3.13 ± 0.21 which indicated severe anemia. After treatment with hematinic drug, 9 patients were died within 3 days of treatment whether one patient was survived. The blood parameter of this live patient increased around normal range at 12^{th} day after treatment (table-5).

Table 5: Blood parameter resulted from before and after treatment with blood transfusion or hematinic drugs (N= 23)

Parameters	Blood Transfusion (n=13) (Mean ± SD)	Hematinic drug treatment (n=10) (Mean ± SD)
Pre-transfusion/ Treatment		
TEC (million/cumm)	3.78 ± 0.38	3.36 ± 0.29
PCV (%)	11.46 ± 2.22	9.60 ± 0.69
Hb (g/dl)	3.98 ± 0.62	3.13 ± 0.21
ESR (mm/1st hour)	1.91 ± 0.49	2.42 ± 0.25
TP (g/dl)	2.04 ± 0.14	1.97 ± 0.15
Post-transfusion/Treatment		
Day 3	(n=13)	(n=1)
TEC (million/cumm)	4.39 ± 1.04	4.0
PCV (%)	12.85 ± 2.67	10
Hb (g/dl)	4.23 ± 0.57	3.6
ESR (mm/1st hour)	1.52 ± 0.46	2.0
TP (g/dl)	2.39 ± 0.30	2.3
Day 6		
TEC** (million/cumm)	5.14 ± 1.25	4.4
PCV** (%)	15.30 ± 2.49	11
Hb** (g/dl)	4.71 ± 0.64	3.8
ESR* (mm/1st hour)	0.86 ± 0.42	1.7
TP** (g/dl)	2.98 ± 0.41	2.6
Day 9		
TEC** (million/cumm)	5.71 ± 1.53	4.7
PCV** (%)	18 ± 2.54	13
Hb** (g/dl)	5.31 ± 0.65	4.0
ESR* (mm/1st hour)	0.50 ± 0.21	1.5
TP** (g/dl)	3.37 ± 0.42	2.8
Day 12		
TEC** (million/cumm)	7.29 ± 1.33	5.0
PCV** (%)	20.53 ± 2.78	15
Hb** (g/dl)	6.15 ± 0.58	4.3
ESR* (mm/1st hour)	0.29 ± 0.20	1.2
TP** (g/dl)	3.88 ± 0.27	3.0

Parameters are listed in this table: TEC- Total erythrocyte count , PCV-Packed cell volume, Hb-Hemoglobin, ESR- Erythrocyte sedimentation rate, TP- Total protein.
** Mark parameters significantly increased in this study ($p < 0.05$)
* Mark parameter decreased significantly in this study ($p < 0.01$)

In the present study, table 5 represented the TEC, PCV, Hb, ESR and TP in two groups- blood transfusion and hematinic group. Important clinical observations during blood transfusion were laid out in table 7.

Blood parameters before and after treatment of 23 anemic patients this study were presented in table 5. Different blood parameter values at 3^{rd}, 6^{th}, 9^{th} and 12^{th} days after treatment were laid out in this table. After hematological examination it was noted that all the patients in group II were of PCV of 9-12% with lower TEC, Hb, ESR and TP and 8 patients of group I were within the same PCV and other parameters.

Annex II presented the blood parameter of goats that were treated with whole blood. This table mainly presented the increase or decrease of blood parameter and significance of the change of parameter between pre-transfusion and post-transfusion (3^{rd}, 6^{th}, 9^{th} and 12^{th} day of experiment) period.

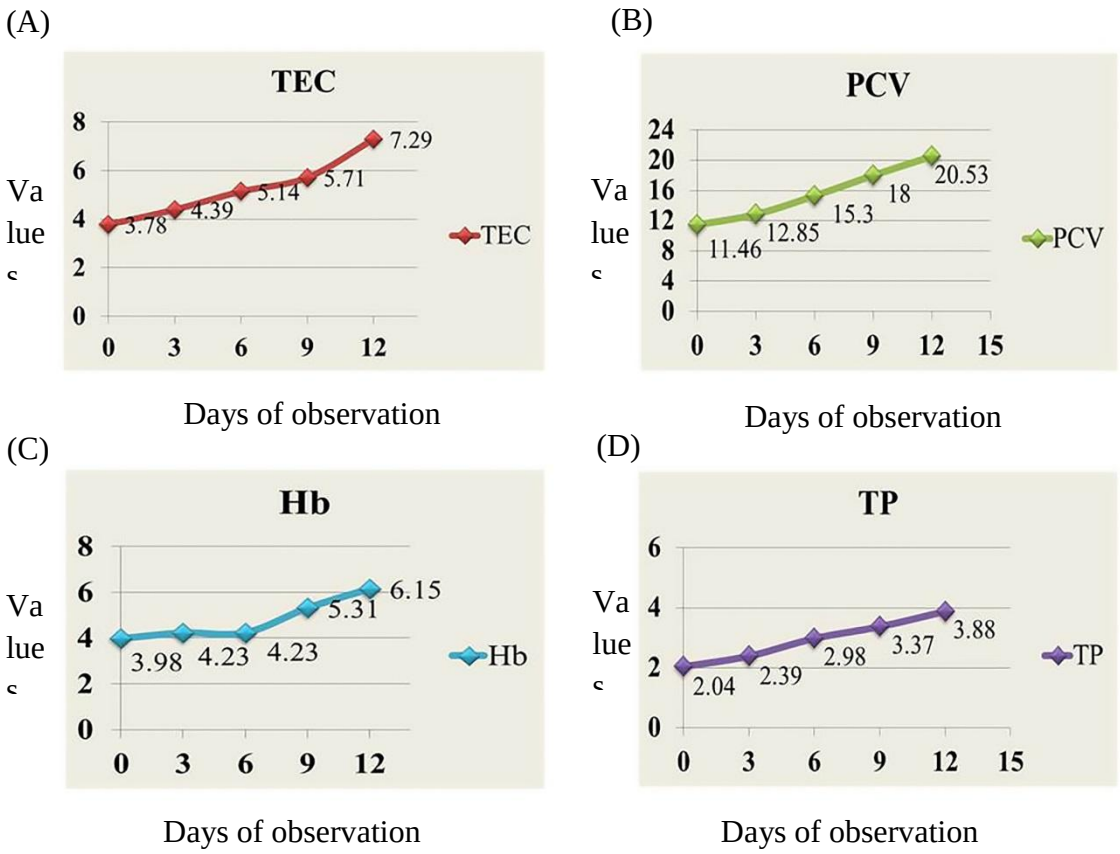


Figure-4: Graphical presentation of changes of blood parameters after blood transfusion

These graphs represented the advancement of TEC (A), PCV (B), Hb (C) and TP (D) parameters before transfusion (0 day) to after transfusion (3rd, 6th, 9th and 12th days of experiment). From this presentation it was also noticed that these parameters increasing day by day. At day 0 when these parameters were severely less than normal level, at 12 days these were nearly the level of normal values with significant change ($P < 0.05$).

Table 6: Effect of whole blood transfusion on breeds

Breed	Population			Result after treatment	
	Group I	Group II	Total	Successful	
				Group I	Group II
Black bengal	4	3	7	4 (100%)	1 (33.33%)
Cross (Jamunapari × Black Bengal)	9	7	16	9 (100%)	0

Table 6 presented the comparative result of success rate for blood transfusion in two types of breeds (Black Bengal and cross). This table presented 100% successful result in cross breed goats both for group I and group II whereas in Black Bengal goat (group I) showed 100% successful result and group II showed 33.33% success rate according to its population. Considering blood transfusion, there is no significant difference between the two considered breed in this study.

Table 7: Common clinical observations during blood transfusion

Clinical observation	During blood transfusion			
	5 mins	10-20 mins	20-40 mins	No sign
Restlessness*	-	5/13	2/13	6/13
Tachycardia*	-	8/13	1/13	4/13
Micturition	-	4/13	6/13	3/13
Defecation	-	-	3/13	10/13
Rumination	-	-	4/13	9/13

*More common sign at the time of transfusion; chance to be confused with reaction

During blood transfusion important clinical signs were taken to find out presence of any transfusion reaction. In this study, within first 5 minutes of blood transfusion there was no detectable change on clinical sign. However, within 10- 40 minutes, different signs were observed like restlessness, tachycardia, micturition, defecation and rumination, which were not actually stated as transfusion reactions. Tachycardia (9 patients) and micturition (10 patients) were found in highest number of recipients during blood transfusion (table-7).

CHAPTER-IV

DISCUSSION

Discussion

Transfusion of blood and blood components as a specialized modality of patient management saves millions of lives worldwide each year. But over the last few years, the benefits of blood transfusion have been questioned because of the connection between this practice and adverse effects. In this study, homologous blood transfusion was performed, because it is the most common form of transfusion for ruminants and the literature is unanimous in stating that ruminants receiving a first transfusion rarely present transfusion reactions.

From the result of this study, the mean values of TEC, PCV and Hb were increased after transfusion compared to mean values before transfusion. The changes of these parameters were not significant ($P > 0.05$) in 3rd day of transfusion. However, these values were significantly changed ($P < 0.05$) at day 6, 9, and 12 of blood transfusion. The significant changes of TEC was due to the action of erythropoietin present in transfused blood by the mechanism of erythropoiesis (Rahaman *et al*. 2003). The highest increased significant level of PCV and Hb at day 12 was observed which is around normal hematological parameter were also associated with transfused blood (Pape *et al*, 2009).

In healthy goat, little or no erythrocyte sedimentation was encountered. In present study, the ESR values gradually decreased before transfusion to different observation days after transfusion. Significant declinations ($P < 0.05$) were observed in ESR values at day 6, 9 and 12 after transfusion. It was due to increased amount of erythrocytes by transfused blood. This finding is in aggrement with the reports of Rahman *et al*., 2003 and Sousa *et al*., 2012.

In this study, total protein increased significantly ($P < 0.05$) after blood transfusion and was maintained throughout the 12 days of experiment. The gradual increased values of TP in recipient at post-transfusion were due to plasma proteins present in transfused blood.

The mean values of total leucocyte count before transfusion were within the normal range of any healthy goat. After transfusion, TLC increased significantly but it remained within normal range. The increase of total leukocytes might be due to epinephrine released at stress condition inducing granulocytosis and finally resulting increased leukocytes (Kaltungo *et al*. 2016).

In this present study, the animals of the hematinic treatment group showed PCV 9-12% before treatment. After treatment with hematinic drugs 1 out of 1o patients was survived during the study period. The cause of death was severe anemia and may be hematinic drugs were not able to do the correction of anemia. Previous study reported if the packed cell volume decreased below 20% and in chronic anemia below 12 to15%, blood transfusion obviously required (Muir *et al*., 2007). Similarly PCV level as a indicator for the blood transfusion was also reported by previous study (Mequanent *et al*., 2018 and Godinho-cunha *et al*., 2011). Out of 13 patients of blood transfusion group, single patient contained 17% PCV level and the remaining 12 patients contained 9 to 13% PCV level that indicated that most of the patients were severe anemic and blood transfusion was definitely required to save the life. After blood transfusion, all patients having 9-13% PCV were recovered successfully and showed significant changes of TEC, PCV, Hb and TP.

In this study, blood from donor was collected in human blood collection bag (closed method) containing anticoagulant citrate, phosphate dextrose and adenine solution. Use of anticoagulant CPDA-1 was supported by Mequanent *et al*., (2018) where he reported CPDA-1 was considered as better anticoagulant because it maintained higher levels of 2, 3-disphosphoglycerate (2, 3-DPG) and adenosine triphosphate (ATP) in collected blood. But in previous studies of Bangladesh, sterile plastic container (open system collection method) was used for blood and plasma transfusion in calves by Rahman *et al*., (2003) and Alam *et al*., (2000) respectively. In open system of blood collection, blood and blood components were more exposed to environmental contamination and were unsuitable for storage (Mudge, 2014). The closed system of blood collection was comparatively safer than open system due to less contamination resulting maintenance of more asepsis.

Observation of clinical parameters during blood transfusion is very important because it may mislead the transfusion reaction. There were several reviews in the veterinary literature on blood transfusions in cats, dogs, and horses about the incidence and type of transfusion reactions ranging from 3 – 13% (Hurcombe *et al*., 2005). However, previous studies reported adverse reactions in large animal blood transfusion are underscoring and needs for further experiment on their identification and prevention (Weinstein, 2010). In this study, restlessness, micturition, tachycardia, defecation and rumination were the most common observable parameters during transfusion.

From the clinical observations during the transfusion period, among 13 recipients highest 10 patients showed the sign of micturition and 9 showed the sign of tachycardia. The possible cause of tachycardia was the administration of sudden large volume of blood in severely anemic animals that were adopted with a low volume of blood circulation for a particular period. From previous study of Hunt and Wood, (1999), it was found that the blood infusion rate to severely anemic goats cannot be only reason for this type of tachycardia. Tachycardia can also occur due to the circulatory overload as a transfusion reaction, but it is usually associated with pulmonary edema which was supported by Sousa *et al*., (2012) and Ognean *et al.*, (2015). Moreover, this present study showed tachycardia during the blood transfusion period but Sousa *et al*., (2014) found tachycardia after 48 hours of blood transfusion as an acute response of receiving blood.

In this study, micturition and defecation were found in 10 patients and 3 patients respectively out of 13 patients. In animal body kidneys are the main organs that suffer much due to vasoconstriction and hypoxia as a result of severe anemia, since blood is directed towards vital organs like brain, heart and lungs (Bitterman *et al*., 1996). In severe anemia kidneys participate to compensate the condition by reducing urine production to maintain a greater quantity of fluid in the blood vessels. After blood transfusion, the increased infused blood stimulates vasodilation and the kidneys began to function better, stimulating diuresis.

Normally, the gastrointestinal blood flow is managed by intestinal and mesenteric veins. So, when anemia is found, sympathetic vasoconstriction is also occurred in these veins, thus diverts large quantities of blood to other parts of circulation. So, at

anemic condition sudden infusion of blood in the circulation of gastrointestinal tract, signals the organ to function normally resulting defecation.

Restlessness and tachycardia were common signs of transfusion reaction when circulatory overload was found (Mamak and Aytekin, 2012). But in this present study, six patients showed restlessness which was mainly due to sudden increase of blood volume in the circulation. No adversible transfusion reaction was found in this study during transfusion and post-transfusion observation time. However, transfusion of fresh and stored total blood improved the blood parameter indices.

CHAPTER-VI

CONCLUSIONS

Conclusions

In this study, blood transfusion was very much effective to save the severely anemic goats in comparison to the commonly practiced hematinic drug treatment in the field. In hematinic drug treatment group, nine animals died among 10 patients whereas in blood transfusion group, 13 patients were successfully recovered within 12 days of post transfusion with mean total erythrocyte count (TEC) 7.29 ± 1.33, packed cell volume (PCV) 20.53 ± 2.78 and hemoglobin (Hb) 6.15 ± 0.58 significantly. Among these 13 patients of blood transfusion group, 8 patients were also within the PCV of 9-12% (before transfusion) similar to PCV of hematinic drug treatment group. So, it was noticeably stated that whole blood transfusion contributed to a greater recovery rate of caprine patients in critical state and unfavorable prognosis of anemia. For goat, this clinical practice has shown that animals receiving a first transfusion can exhibit few clinical changes; however it gave successful recovery from anemic condition. So, this study conveyed contributions to the field of caprine blood transfusion therapy in clinics and field with limited investment and excellent recovery. Finally, this study was justified to confirm the therapeutic efficacy of whole blood transfusion in goat.

CHAPTER-VII

RECOMMENDATION

Recommendation

Though a significantly positive conclusion was found in this study, however, large sized population will provide more specified result for better conclusion. It is also suggested that blood transfusion can be given on the basis of more specified cause of anemia relating to cause, blood transfusion and efficacy of blood transfusion on the basis of etiology of anemia. In the present study, only whole blood transfusion was done successfully. Furthermore, transfusion of different types of blood products like RBC, plasma transfusion can also be continued in goats for future.

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Annex-I

Questionnaire for establishment of a modified blood transfusion protocol for severely anemic goat in Bangladesh

Case Registration no.:

Category of case: Medicine/ Surgery/ Gynaecology

1. Owner's name: Contact no.:

   Address:

2. Patient's information:

   Age: Sex: Breed: BB/ Jamunapari/ Cross

   Feeding history: Normal/ Off feed Weight:

   Mucous membrane: White/Severe pale/Mild pale/ Pink

   Deworming: Yes/ No Ecto-parasite: Yes/ No

   Dehydration: Yes/ No Weakness: Yes/ No

3. Additional findings:

4. **Diagnosis:**

5. Observation of common clinical parameters before and after treatment:

Observation	Before treatment	During transfusion					After transfusion			
		05 mins	10 mins	15 mins	30 mins	1 hr	3rd days	6th days	9th days	12th days
Heart rate										
Respiration rate										
Temperature										

Observation	During transfusion					After transfusion			
	05 mins	10 mins	15 mins	30 mins	1 hr	3rd days	6th days	9th days	12th days
Restlessness									
Tremor									
Micturition									
Defecation									
Tachycardia									
Allergy									
Rumination									

Annex- II

Parameters	Before transfusion Mean± SE (A)	After transfusion				*p* (ANOVA)	*p (post-hoc test)*
		3rd day Mean± SE (B)	6th day Mean± SE (C)	9th day Mean± SE (D)	12th day Mean± SE (E)		
Total erythrocyte count (10^6/ ml)	3.78± 0.38	4.39 ± 1.04	5.14 ± 1.25	5.71 ± 1.53	7.29 ± 1.33	0.001	1.000 (A vs B); 0.049 (A vs C); 0.001 (A vs D); 0.00 (A vs E)
Hemoglobin (g/dl)	3.98 ± 0.62	4.23 ± 0.57	4.71 ± 0.64	5.31 ± 0.65	6.15 ± 0.58	0.001	1.000 (A vs B); 0.041 (A vs C); 0.00 (A vs D); 0.00 (A vs E)
Packed cell volume (%)	11.46 ± 2.22	12.85 ± 2.67	15.30 ± 2.49	18 ± 2.54	20.53 ± 2.78	0.001	1.000 (A vs B); 0.003 (A vs C); 0.00 (A vs D); 0.00 (A vs E)
Erythrocyte sedimentation rate (mm/1st hour)	1.91 ± 0.49	1.52 ± 0.46	0.86 ± 0.42	0.50 ± 0.21	0.29 ± 0.20	0.001	0.115 (A vs B); 0.00 (A vs C); 0.00 (A vs D); 0.00 (A vs E)
Total protein (g/dl)	2.04 ± 0.14	2.39 ± 0.30	2.98 ± 0.41	3.37 ± 0.42	3.88 ± 0.27	0.001	1.000 (A vs B); 0.049 (A vs C); 0.001 (A vs D); 0.00 (A vs E)

Annex-III: Raw data

Blood transfusion group:

Total erythrocyte count (million/cumm):

Patients	Before transfusion	After transfusion			
		3^{rd}	6^{th}	9^{th}	12^{th}
1	4.49	7.6	8.95	10.48	11.46
2	4.12	4.16	4.64	5.2	6.8
3	4	4.1	4.2	5.1	7
4	3.8	3.9	4.2	5.8	7.4
5	4	4.2	4.7	5.1	7.2
6	3.4	3.9	4.9	5.1	7.1
7	3.8	4	5	5.4	6.7
8	3.9	4.8	5.4	5.8	7.2
9	4.2	5.1	6.1	6.8	7.8
10	3.2	3.7	4.4	4.6	6.4
11	3.4	3.9	4.9	5	7.1
12	3.6	4	4.9	5.1	6.8
13	3.3	3.7	4.5	4.8	5.9

Packed cell volume (%):

Patients	Before transfusion	After transfusion			
		3rd	6th	9th	12th
1	17	20	22	25	28
2	14	15	16	18	20
3	12	12	14	18	21
4	11	12	15	19	22
5	11	12	14	18	21
6	10	12	15	17	19
7	11	12	15	18	19
8	12	14	16	18	21
9	13	15	18	20	23
10	9	10	12	15	17
11	10	12	15	16	19
12	10	11	14	17	19
13	9	10	13	15	18

Hemoglobin (g/dl):

Patients	Before transfusion	After transfusion			
		3rd	6th	9th	12th
1	5.3	5.3	5.8	6.8	7.4
2	4.9	4.9	5.1	5.4	6
3	4.2	4.3	4.8	5.2	6
4	4	4.2	4.7	5.3	6.4
5	3.9	4.1	4.7	5.6	6.2
6	3.6	3.9	4.2	5	5.9
7	3.9	4.1	4.6	5.2	5.4
8	4	4.7	5	5.2	6.2
9	4.4	4.9	6	6.3	7.2
10	3.2	3.5	4	4.4	6
11	3.6	3.9	4.2	4.9	5.9
12	3.8	3.8	4.2	5.2	6
13	3	3.4	3.9	4.5	5.4

Erthrocyte sedimentation rate (mm/1st hour):

Patients	Before transfusion	After transfusion			
		3rd	6th	9th	12th
1	1	0.5	0.3	0.1	0.1
2	1.3	1	0.7	0.4	0.1
3	1.6	1.4	1.1	0.5	0.1
4	2	1.8	0.8	0.4	0.2
5	2.1	1.7	0.9	0.6	0.1
6	2.2	1.5	0.7	0.5	0.4
7	2	1.7	0.7	0.6	0.4
8	1.7	1.2	0.6	0.5	0.2
9	1.3	1.1	0.4	0.2	0.1
10	2.6	2.1	1.8	0.8	0.7
11	2.3	1.8	0.8	0.6	0.5
12	2.3	1.9	0.9	0.5	0.4
13	2.5	2.1	1.6	0.9	0.5

Total protein (gm/dl):

Patients	Before transfusion	After transfusion			
		3rd	6th	9th	12th
1	2.16	3.26	3.5	3.8	4.6
2	2.2	2.47	3.2	3.7	3.8
3	2.1	2.28	2.48	3.8	3.94
4	2	2.3	3.3	3.8	4
5	2.1	2.35	3.1	3.5	3.8
6	2.27	2.44	3.2	3.4	3.87
7	2.1	2.4	3.1	3.5	3.64
8	2	2.46	3.3	3.48	3.9
9	2.2	2.5	3.4	3.58	4.16
10	1.8	2	2.28	2.6	3.5
11	1.9	2.3	2.5	2.9	3.76
12	2	2.3	3	3.2	3.8
13	1.8	2	2.4	2.6	3.7

Hematinic treatment group:

Before treatment

Patients	TEC (million/cumm)	PCV (%)	Hb (gm/dl)	ESR (mm/1st hr)	TP (gm/dl)
1	3.2	10	3	2.5	2.17
2	3.8	12	3.3	2	2.1
3	3.9	10	3.5	2	2.2
4	3.3	9	3.2	2.4	1.8
5	3	9	3.1	2.8	1.8
6	3.2	10	2.8	2.5	1.9
7	3.5	10	3.3	2.4	2
8	3.2	9	3	2.5	1.8
9	3.4	9	3.2	2.4	1.9
10	3.1	9	2.9	2.7	2

Biography

Tuli Dey is a candidate for the degree of MS in Surgery under the department of Medicine and Surgery, Faculty of Veterinary Medicine, CVASU. She has passed the secondary school certificate (SSC) in 2007 and then higher secondary certificate (HSC) examination in 2009. She has obtained her Doctor of Veterinary Medicine (DVM) in 2014 (held on 2015) from CVASU, Bangladesh. During her undergraduate period, she has received clinical training on veterinary medicine from Tamilnadu Veterinary and Animal Sciences University, India and also visited Tufts Cummings School of Veterinary Medicine, USA to work as short term scholar. She has achieved Dean's award for her academic excellence. Now, she is working as lecturer at surgery unit, Department of Medicine and Surgery, CVASU. She has published several scientific articles in national and international journals. She has great interest on transfusion medicine and veterinary anesthesiology.