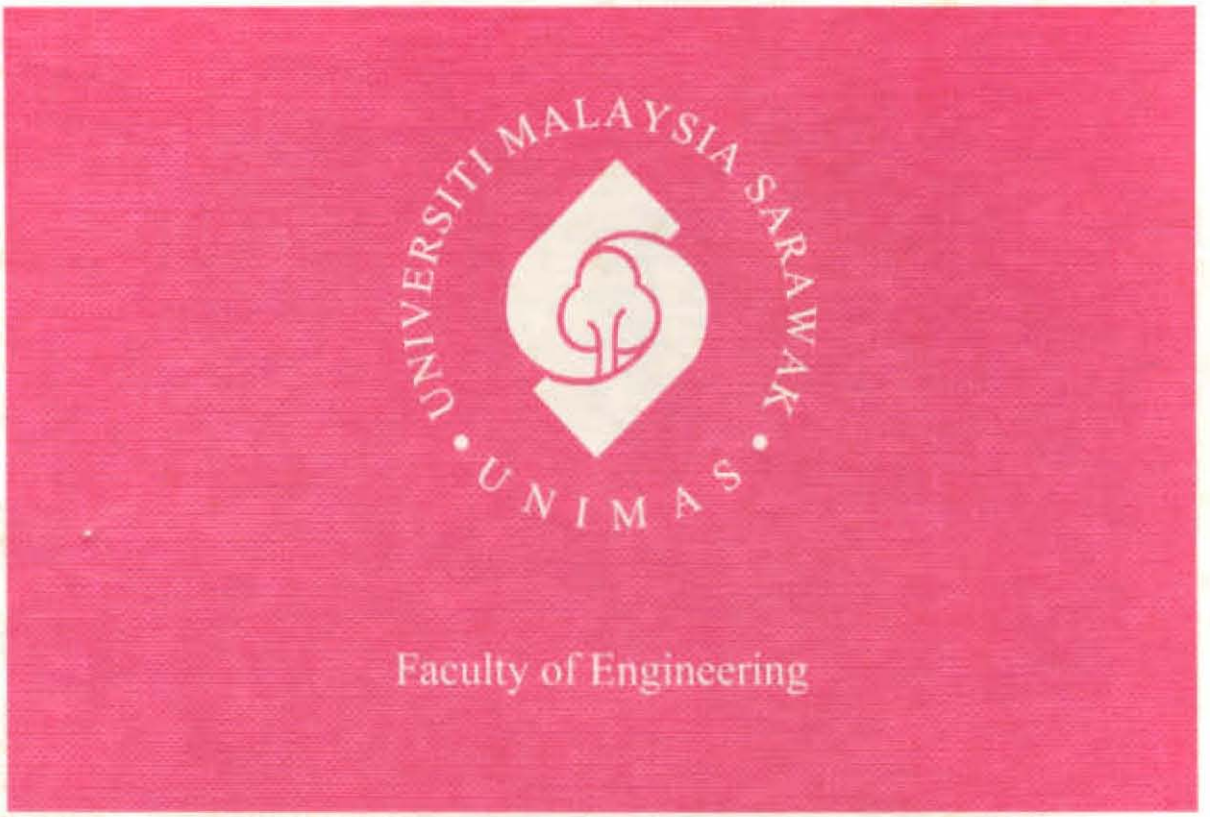

FUNDAMENTAL STUDY ON THE MECHANISM OF BLOOD WITHDRAWAL OF MOSQUITO

AWANG RAHIM BIN OSMAN

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12/6/2008

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FUNDAMENTAL STUDY ON THE MECHANISM OF BLOOD WITHDRAWAL OF MOSQUITO

AWANG RAHIM BIN OSMAN

This report is submitted in partial fulfillment of the requirement of the

Degree of Bachelor of Engineering with Honours in

Mechanical & Manufacturing Engineering from the

Faculty of Engineering

University Malaysia Sarawak

2008

Dedicated to the strength of my family and the memory of my brother...

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First and foremost I would like to thank GOD for giving me the strength to undergo my Degree of Bachelor of Engineering with Honours in Mechanical & Manufacturing Engineering, and for me to accomplish this particular project and any upcoming challenges. I would also like to gratitude Mr. Noor Hisyam Noor Mohamed and Mr. Danial Ibrahim for giving me this opportunity to work on this project and for all his guidance to get this project done. Not forgotten to my parent who have been my backbone all this while anytime anywhere around. I would like to thank to all friends who have been involve directly, or indirectly especially to 4th year medical students, who have been helping me in this project. None of this would have been possible without the guidance of the above mentioned people.

ABSTRAK

Objektif kajian ini ialah untuk mendalami kefahaman tentang mekanisme pengeluaran darah oleh seekor nyamuk daripada saluran darah manusia, dan untuk mengetahui kaedah pengeluaran darah dengan mudah dan tiada kesakitan. Kajian dalam pembangunan teknologi jarum mikro telah mengarah kepada pemahaman tentang bagaimana seekor nyamuk boleh menghisap darah tanpa menyebabkan kesakitan terhadap mangsanya. Jika pendekatan ini diaplikasikan dalam kedua-dua mekanik bendalir dan saluran darah *hemo-dinamik*, ini akan membawa faedah kepada pesakit-pesakit diabetis yang perlu dipantau akan kandungan darahnya setiap masa, bayi yang mesti dipantau kandungan gula dalam darahnya, atau sesiapa sahaja yang tidak dapat menggunakan jarum *hypodermic* tradisional. Oleh itu, dengan mempelajari dan memahami mekanisme pengeluaran darah oleh seekor nyamuk dan aplikasikan ia dalam bidang kejuteraan akan membawa kepada penemuan baru. Kajian ini telah menemui bahawa bacaan tekanan yang berbeza pada bukaan *proboscis* yang menembusi *arteriole* pada sudut yang berbeza. Selain daripada itu, perbezaan tekanan pada bukaan *proboscis* mempengaruhi halaju masuk yang mengalir melalui *proboscis* tersebut. Darah boleh mengalir tanpa perlu menghisapnya keluar.

ABSTRACT

The objective of this research is to gain fundamental understanding on the mechanism of blood withdrawal from human blood vessel to have better knowledge on how to withdraw blood without any pain and less effort. In this research, a study on female mosquito is undergone which is known simply able to withdraw blood with ease and painless. If this approach is put together with both fluid mechanics and human blood vessel *hemodynamics*, this would benefit *diabetics*, who extract blood samples multiple times daily, infant who need continuous monitoring of their blood sugar levels, or anyone who cannot tolerate traditional *hypodermic* needles. Thus by studying and understanding the mechanism of blood withdrawal of mosquito and apply it in engineering would lead to new finding. In this research found that various entrance pressure entering into the *proboscis* opening at different piercing angle inside of the blood vessel called *arteriole*. It is also found that the pressure difference at the entrance of the *proboscis* opening significantly influences entrance velocity flowing through the *proboscis*. The blood can even be withdrawn without sucking it out through the micro needle.

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CHAPTER 1

INTRODUCTION

1.1 Project Introduction

Human blood vessel can be subdivided into seven subparts which are *the aorta, artery, capillary, venule, vein,* and *vena cava.* In human *cardiovascular* system, the heart acts as a 'pump' to pump the blood throughout the systemic circulation. Pressure varies in different subpart of vessel is visible. Commonly, different sex also differs in blood pressure, as any women have slightly lower blood pressure, compared to men [2]. Human blood is phasic fluid. It is divided into 2-phase systems, which are the cell and liquid. The *plasma* is 'fluid portion of the blood' [2]. It suspends the cell; consist of the red cell, white cell, and the *platelet.* 8% of particular adult weight is blood. According to Guyton & Hall (2006), 85% of the blood volume is in systemic circulation and the rest is in the heart and lung [3]. However, 64% out of the blood in systemic circulation is in the *vein,* 13% in *artery* and 7% in systemic *arterioles* and *capillaries.*

Cross-sectional area of the *vein* is larger than the *arteries*, and this explains why 64% of the blood in systemic circulation is stored in *venous* mostly. Note that velocity of the blood flow is inversely proportional to *vascular* cross sectional area [3]. Mean pressure in *aorta* is very high at 10mmHg at average velocity of 33cm/sec as the result of the pumped blood continually, directly from the heart. In comparison to *capillaries*, its about 1/1000 of the *aorta* flow. At average velocity of 0.3mm/sec, the blood remains 1-3 seconds in *capillaries* since the length is very short about 0.3mm-1mm [3].

Blood withdrawing techniques nowadays obtain the blood either from the *arteries* or the *veins*. Using the hypodermic needle to withdraw the blood from the *arteries* or *veins* situated just below the skin, this process surely is painful. The metal needle makes contact with the local nerves beneath the skin causing the host feel the pain. For example, most diabetics have to be monitored of their glucose level in the blood 6-8 times daily. Experiencing the blood withdrawing processes many times daily caused trauma within them. The other technique is collecting blood from the fingertip and fed into the meter is extremely painful process because of the lancet used to prick the finger for the blood sample. Repeated use of this procedure leads to numbness to the skin.

It is interesting knowing that the mosquito can suck human blood for feeding without being notice by the host and painless. The host would probably notice redness spot and itching on their skin after the mosquito have gone far. Clement (2000) asserts that only the female mosquito draw blood for egg production, but some evidence also found that it is for energy source too [12]. Note that mosquito do not bite, instead it stings. First, they penetrate the skin with its needle called *fascicle* [12]. This may take

many tries. The mosquito repeatedly applies its tip of *labium* onto the skin surface. As the *fascicle* emerges from *proboscis* and enters the skin, the mosquito first injects anti-coagulant into the blood, to dilute it and keep it from coagulating (turning into a solid) in its stomach. It's the anti-coagulant that causes the allergic reaction on the skin, resulting redness and itching.

1.2 Project Objective

The objective of this project is to do the fundamental study on how to develop micro- needle, which will give less pain or almost no pain to the patient. Micro-needle is in contrast with the conventional syringe needle, which have larger surface area contact between the metal and the skin tissue which cause the pain. This technology would benefit *diabetics*, who need frequent injections to extract blood samples, infant who need continuous level of blood sugar monitoring, or anyone who could not tolerate traditional *hypodermic* needles.

The secret of all this is kept by the Mother Nature, where the mosquito has the answer for this research in additional to blood vessel study within ourselves too. The initial bite is painless because the mosquito's *proboscis* is highly serrated. The edge of the proboscis leaves a very small point in contact to skin tissue which will significantly reduce stimulation of the nerves in the skin. Thus the understanding on the ability of mosquito to penetrate skin and withdraw blood from the blood vessel below the skin

epidermis without pain can be considered as the fundamental for the micro-needle technology.

1.3 Project Preview

The fundamental study on developing the micro-needle begin with the understanding on how the mosquito is able to withdraw blood by penetrating the skin epidermis without being notice by the human body when its *proboscis* piercing the skin. The *proboscis* of the mosquito have 30μm-50μm in diameter, that is probably couldn't withdraw blood from the *capillaries* having mean diameter of 10μm-20μm. Thus the *fascicle* of the mouthpart could only withdraw human blood between larger *arterioles* and *venules*.

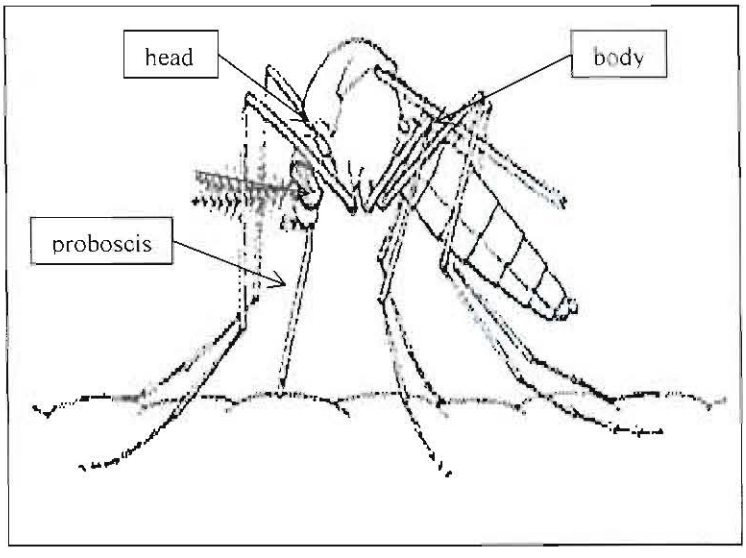

Figure 1: Proboscis is used to withdraw blood by piercing the human skin.

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To achieve such small diameter and length of only 1mm, it could be the main challenge to accomplish perfectly at this very moment. Nevertheless, by understanding the human blood vessel plus the deeper research in mosquito mouth part, this research could, if successfully done, contribute in the research of developing the micro technology and nanotechnology of bio-engineering.

1.4 Project Outline

This research will cover the basis knowledge on human blood vessel, *hemodynamics*, mathematical equations governing the research, blood mechanics, mosquito anatomy, and application in engineering field. The systemic circulation and *cardiovascular* system is briefly explained throughout this project. Study of the mosquito anatomy was also included in order to have clearer view of the relation of the human blood vessel and bio-engineering field. Organized work plans of the project are addressed in the Methodology.

CHAPTER 2

LITERATURE REVIEW

This chapter can be divided into three topics which are human blood vessel, fluid mechanics and mosquito entomology. Human blood vessel study will discuss on the three parts of blood vessel which are *capillaries, veins and arteries*. A fundamental study of overall blood vessel is also included and reviewed briefly. The second topic which is fluid mechanics can be divided into two part, *hemodynamics* and blood mechanics. The last topic, mosquito entomology can be divided into four parts, which are mosquito anatomy, mosquito blood feeding, exploration and piercing, and structure of proboscis.

2.0 Study Background

Female mosquito has the secret of the most efficient micro needle-system with 100% reliability and with a totally painless blood withdrawing from host blood vessel. A female mosquito is able to feed on human blood without producing a sensation of pain and without any failure of its needle. The only sensation is itching due to the introduction of mosquito *saliva* which is used to prevent the blood from clotting.

The aim of this research is to understand the human blood vessel, and study the ways to mimic this system for blood withdrawing in a painless manner. A female mosquito is able to draw approximately 2.5 µl of blood per feeding, depend on the species type, which makes the system more attractive as this amount is adequate for blood glucose monitoring and blood examination.

2.1 Human Blood Vessel

Blood vessels are hollow tubes for carrying blood from the heart. Located throughout the body, the blood vessels transport circulating blood from left *ventricle* and back to right *atrium* [1].

According to Ganong (1995) there are seven varieties of blood vessels: *aorta, artery, arteriole, capillary, venule, vein* and *vena cava* [2]. In Figure 1, the arrows indicate the

blood circulation. The *aorta* carries blood away from the heart. The *capillaries* connect the *arteries* to *veins*. Finally, the *veins* carry the blood back to the heart.

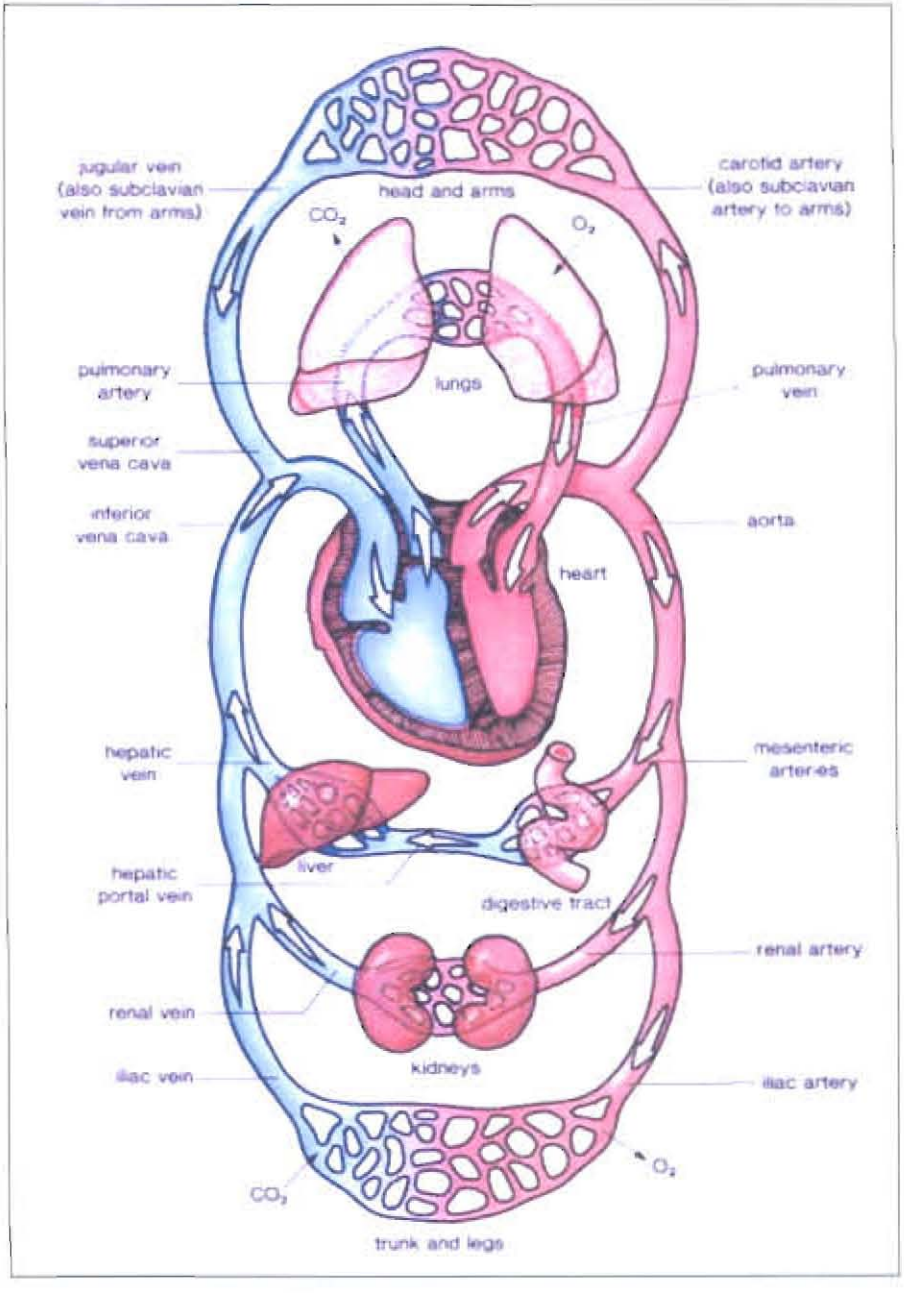

Figure 2: Human *cardiovascular* system. This figure shows the blood is transported throughout the cardiovascular system. [17]