COLOR ATLAS OF

FORENSIC PATHOLOGY

CARDIOVASCULAR DISEASE

MYOCARDIAL INFARCTION

COLOR ATLAS OF FORENSIC PATHOLOGY

Version 1

CARDIOVASCULAR DISEASE

Prof. Dinesh Fernando
MBBS, MD (Forensic Medicine)
DLM, DMJ (Lond)
Dept. of Forensic Medicine

Dr. Sulochana Wijetunge
MBBS, MD (Histopathology)
Dept. of Pathology

Faculty of Medicine,
University of Peradeniya,
Sri Lanka

In case of any questions, comments, suggestions or errors, please mail the authors on dineshf@pdn.ac.lk / dineshmgfdo@yahoo.com or sulochana.wijetunge@med.pdn.ac.lk.

ISBN: **978-624-96229-0-6**

Last updated on 10/07/2020

FOREWORD

The greatest pleasure I experience as a teacher, is to see my students excel in their chosen careers and perform even better than myself. The series of e-booklets prepared to better equip medical officers to handle common conditions likely to be encountered in their day to day forensic practice by Professor Dinesh Fernando, is a good example of one of my students doing better than me!

Dinesh is the son of Emeritus Professor of Community Medicine, Former Head, Department of Community Medicine, Former Dean, Faculty of Medicine and Vice Chancellor of the University of Peradeniya, Malcolm Fernando, who was an illustrious medical academic. Following his father's footsteps, he joined the University of Peradeniya in 2003.

Dinesh was one of my post graduate trainees at the Department of Forensic Medicine and Toxicology, Faculty of Medicine, Colombo, and obtained the doctorate in Forensic Medicine in 2003. He underwent post-doctoral training at the Victorian Institute of Forensic Medicine, Melbourne, Australia, with my colleague and contemporary at Guy's Hospital Medical School, University of London, Professor Stephen Cordner. During this period, he served as the honorary forensic pathologist of the Disaster Victim Identification team in Phuket, Thailand following the tsunami, and was awarded an operations medal by the Australian Federal Police.

He has edited, and contributed chapters to, 'Lecture Notes in Forensic Medicine' authored by the former Chief Judicial Medical Officer, Colombo, Dr. L.B.L. de Alwis and contributed to 'Notes on Forensic Medicine and Medical Law' by Dr. Hemamal Jayawardena. He is the editor of the Sri Lanka Journal of Forensic Medicine, Science and Law. Continuing his writing capabilities, he has compiled an important and unique set of e-booklets which will be a great asset to undergraduate and post-graduate students of Forensic Medicine, and also to our colleagues. Its succinct descriptions of complicated medico-legal issues and clear and educational photographs are excellent. It makes it easy for the students to assimilate the theoretical knowledge of each topic as they have been augmented with histories, examination findings, macroscopic and microscopic photographs of actual cases. In some areas, photographs from multiple cases have been included, so that the students can better appreciate the subtle differences that would be encountered in their practice.

I sincerely thank my ever so grateful student Dinesh, for giving me this great honour and privilege to write the foreword.

Professor Ravindra Fernando

MBBS, MD, FCCP, FCGP, DMJ (London), FRCP (London)
FRCP (Glasgow), FRCP (Edinburgh), FRCPath. (UK)

Senior Professor of Forensic Medicine, General Sir John Kotelawala Defence University, Ratmalana.
Emeritus Professor of Forensic Medicine and Toxicology, Faculty of Medicine, University of Colombo

About the Authors.....

Dr. Sulochana Wijetunge is a Senior Lecturer serving at the Department of Pathology, Faculty of Medicine, University of Peradeniya and Teaching Hospital, Peradeniya. She obtained her undergraduate education at the Faculty of Medicine, University of Colombo, and her postgraduate training from Postgraduate Institute of Medicine, University of Colombo, Sri Lanka. International exposure includes training at the University of Southern California, USA and Royal Marsden NHS Foundation Trust, UK. She has 17 years of experience in undergraduate teaching and 12 years of experience as a board certified histopathologist and a post graduate trainer. She has an interest in forensic histopathology and trains the forensic medicine postgraduate students in Pathology.

Dr. Dinesh Fernando is a merit Professor in Forensic Medicine at the Faculty of Medicine, University of Peradeniya and honorary Judicial Medical Officer, Teaching Hospital Peradeniya. He obtained his MBBS in 1994 with Second class honours from the North Colombo Medical College, Sri Lanka, and was board certified as a specialist in Forensic Medicine in 2004. He obtained the postgraduate Diploma in Medical Jurisprudence in Pathology from London in 2005, and possesses a certificate of eligibility for specialist registration by the General Medical Council, UK. He underwent post-doctoral training at the Victorian Institute of Forensic Medicine, Melbourne, Australia. He has also worked at the Wellington hospital, New Zealand, as a locum Forensic Pathologist and as an Honorary Clinical Senior Lecturer at the Wellington School of Medicine and Health Sciences, University of Otago, New Zealand. He was invited to visit and share experiences by the Netherlands Forensic Institute in 2019.

PREFACE

Forensic Medicine in Sri Lanka encompasses, both, examination of patients for medico-legal purposes and conducting autopsies in all unnatural deaths, in addition to those that the cause of death is not known. In the eyes of the justice system in Sri Lanka, all MBBS qualified medical officers are deemed to be competent to conduct, report and give evidence on medico-legal examinations of patients and autopsies conducted by them, as an expert witness. However, during their undergraduate training, they may not get the opportunity to assist, nor observe, a sufficient variety of representative of cases that may be encountered in the future.

Therefore, a series of e-booklets has been prepared to better equip medical officers to handle common conditions that are likely to be encountered in day to day forensic practice. The case histories and macro images are from cases conducted by Prof. Dinesh Fernando, while the microscopic images are from the collections of, either, Prof. Dinesh Fernando or Dr. Sulochana Wijetunge. The selection, photography, reporting of all microscopic images and the short introductions of the pathology of each condition was done by Dr. Sulochana Wijetunge. Most of the macro images used were taken by Louise Goossens – a medical photographer par excellence.

Dr. Madhawa Rajapakshe contributed immensely in preparing the photographs for publication. Ms. Chaya Wickramarathne did a yeomen service in design, lay out and formatting the booklet. If not for the many hours she spent in discussing with the two authors, and editing these cases over several months, these booklets would not have seen the light of day. This is being continued by Ms. Isuruni Thilakarathne.

The content herein may be used for academic purposes with due credit given. Any clarifications, suggestions, comments or corrections are welcome.

Prof. Dinesh Fernando
Dr. Sulochana Wijetunge

Table of Contents

CARDIOVASCULAR DISEASE

MYOCARDIAL INFARCTION

Identification and dating of an acute myocardial infarction

Immediately after an acute myocardial infarction (AMI) there are usually no macroscopically or microscopically detectable changes in the myocardium. Initial macroscopic changes occur after about 12 hours and microscopic changes after about 4-6 hours. Therefore, post mortems performed on patients died soon after an AMI may not show any changes in the myocardium.

Given below are the histological criteria to identify and determine the age of a myocardial infarction. It should be noted that the given time sequence for evolution of an infarction could vary depending on many variables including the macro and micro environmental changes. Furthermore, neither of these changes starts or ends abruptly; they appear gradually, reach a peak and then wane off.

Overall, predominant changes in the first week are those of necrosis and acute inflammatory cells (neutrophils and their debris); the second week macrophages and other mononuclear inflammatory cells predominate and the third week onwards granulation tissue formation and collagen accumulation. However, not infrequently necrotic myocytes may be seen in the centres of the infarcts even in the third week.

The time required for complete healing of an infarction to form a scar is variable and may take about 6 to 7 weeks or longer.

First 12 hours

Macroscopy: No changes usually. However, necrotic areas may be highlighted by nitro- blue tetrazolium

Microscopy

Reliable recognition of myocardial infarctions within the first 12 hours with haematoxylin and eosin stain could be challenging, often the changes are either absent or too subtle to be identified.

Ancillary methods that may be useful to identify changes are:

1. Special stains – nitro- blue tetrazolium
   This special stain can be used on macroscopic sections by painting them or on fresh (unfixed) histology sections.

   Dehydrogenase enzyme present in viable myocytes turns the chemical into a deep blue colour. Therefore, the viable tissue stains blue and dead tissue remains unstained.

Figure 1:Negative, showing an even purple stained myocardium without discolouration, implying no ischaemic changes

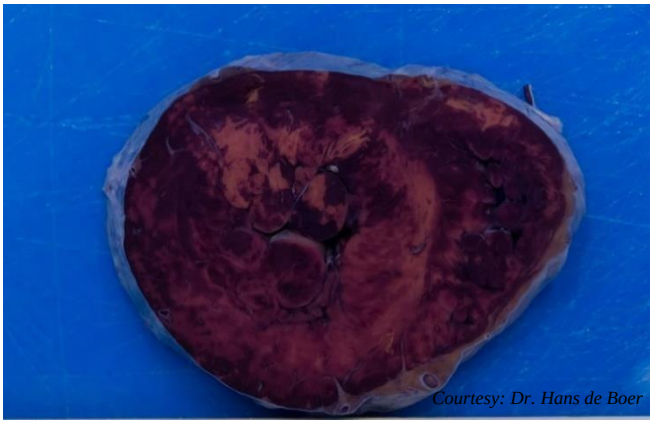


Figure 2: Yellow area in the dorsal part of the left and right ventricle. This implies necrosis, signalling ischaemic damage of at least about a day

2. Immunohistochemistry

Complement 9 (C9) staining is absent in normal myocardial cells but expressed hypoxic cells and therefore, stains

myocytes which has undergone recent necrosis.

Troponin T is expressed by normal myocardial cells but shows negative staining in necrotic myocardial cells. However, immunohistochemistry is still not widely used to date early infarctions.

Wavy myocardial fibres and contraction bands (see notes below) could appear even during the first 12 hours

12 – 24 hours

Macroscopy: congested appearance or dark mottling due to extravasated red cells. If bleeding is not prominent may appear pale.

Microscopy: Main features are

- Wavy myocardial fibres
- Contraction bands
- Loss of cross striations and cytoplasmic eosinophilia
- Cytoplasmic degeneration may also appear
- Nuclear pyknosis, karyorrhexis and karyolitic.

Wavy myocardial fibres with intercellular oedema and contraction bands start appearing first. The other changes appear later and evolve to be more prominent in the 2nd day.

Wavy myocardial fibres are thinned and stretched myocardial fibres which has gained a wavy appearance and associated with intercellular oedema. Wavy fibres may have resulted from stretching of noncontractile myocytes due to bulging of ischaemic regions during systole.

These fibres may also be seen at the peripheries of older infarcts.

Contraction bands are irregular eosinophilic transverse bands on H &E stain. These bands are clearly seen when stained with phosphotungstic acid haematoxylin (PTAH) which stains the myocytes blue.

This phenomenon is due to intense hypercontraction in dying myocytes due to increase influx of calcium into the cytoplasm that occur with plasma membrane damage. Contraction bands are more prominent in reperfusion injuries and death following ventricular fibrillation; changes are diffuse in the latter situation. Focal collection of myocytes with contractions bands is a reliable indicator of early infarction.

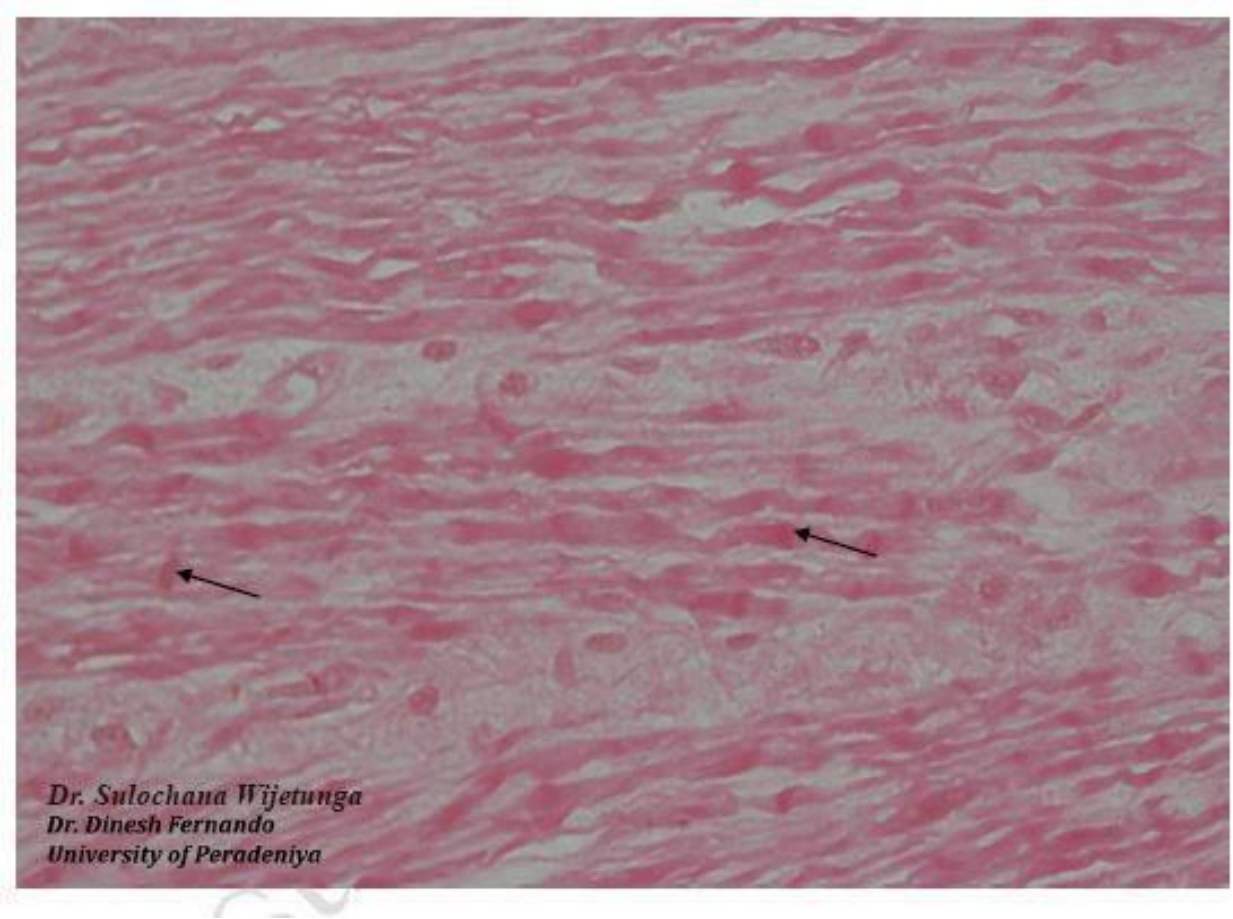


Figure 1: Early myocardial infarction 24 to 48 hours

Contraction bands (arrows) and wavy myocardial fibres

24 to 48 hours

Macroscopy: The infarcted area becomes pale with hyperaemic borders

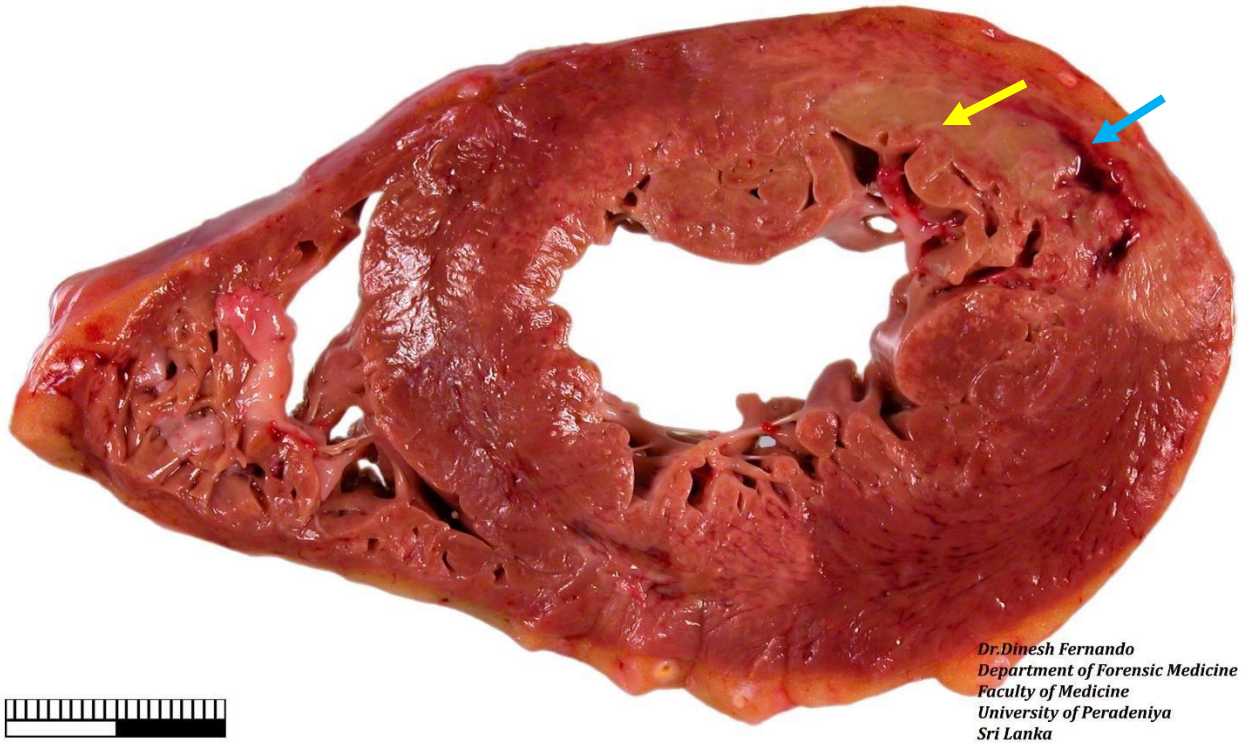


Figure 2: Infarcted area which had become pale (yellow arrow) with hyperaemic borders (blue arrow)

Microscopy: Features are

- Nuclear pyknosis and karyorrhexis.
- Cytoplasmic eosinophilia and degeneration
- Focal areas of haemorrhage into the infarcted area.
- Congested blood vessels in the surrounding viable tissue due to acute inflammatory response in the viable tissue.

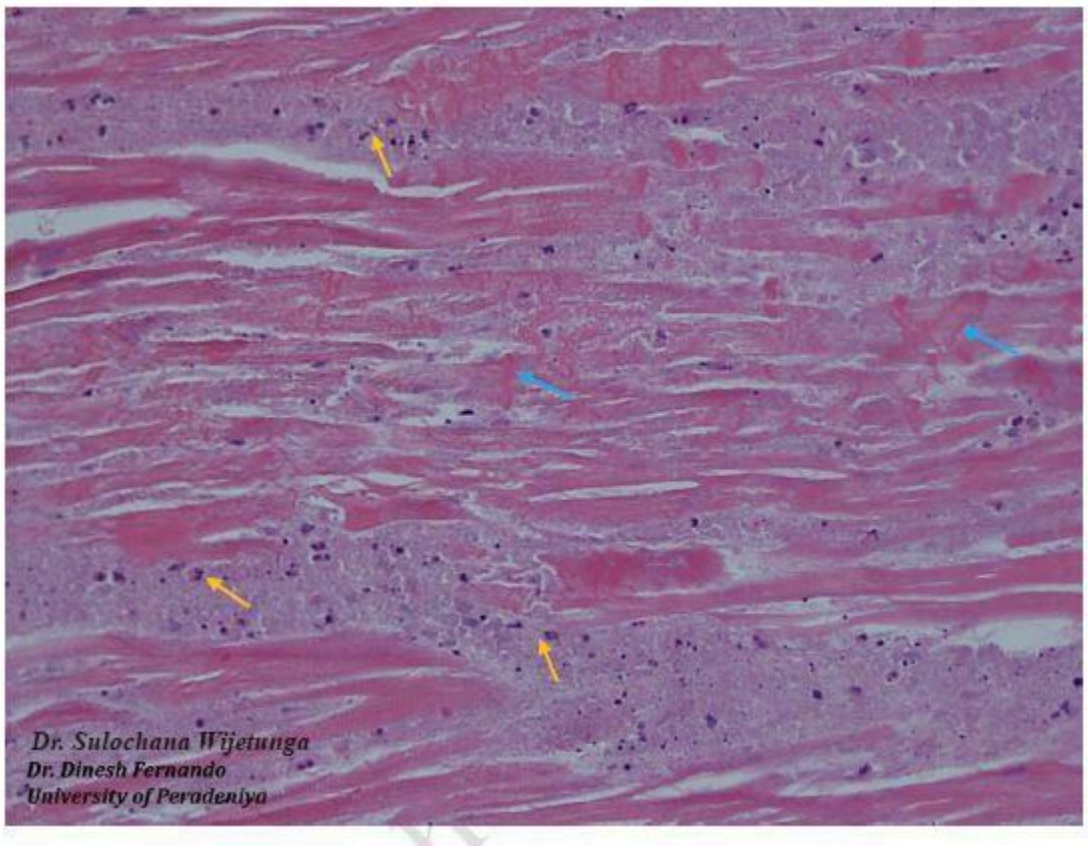


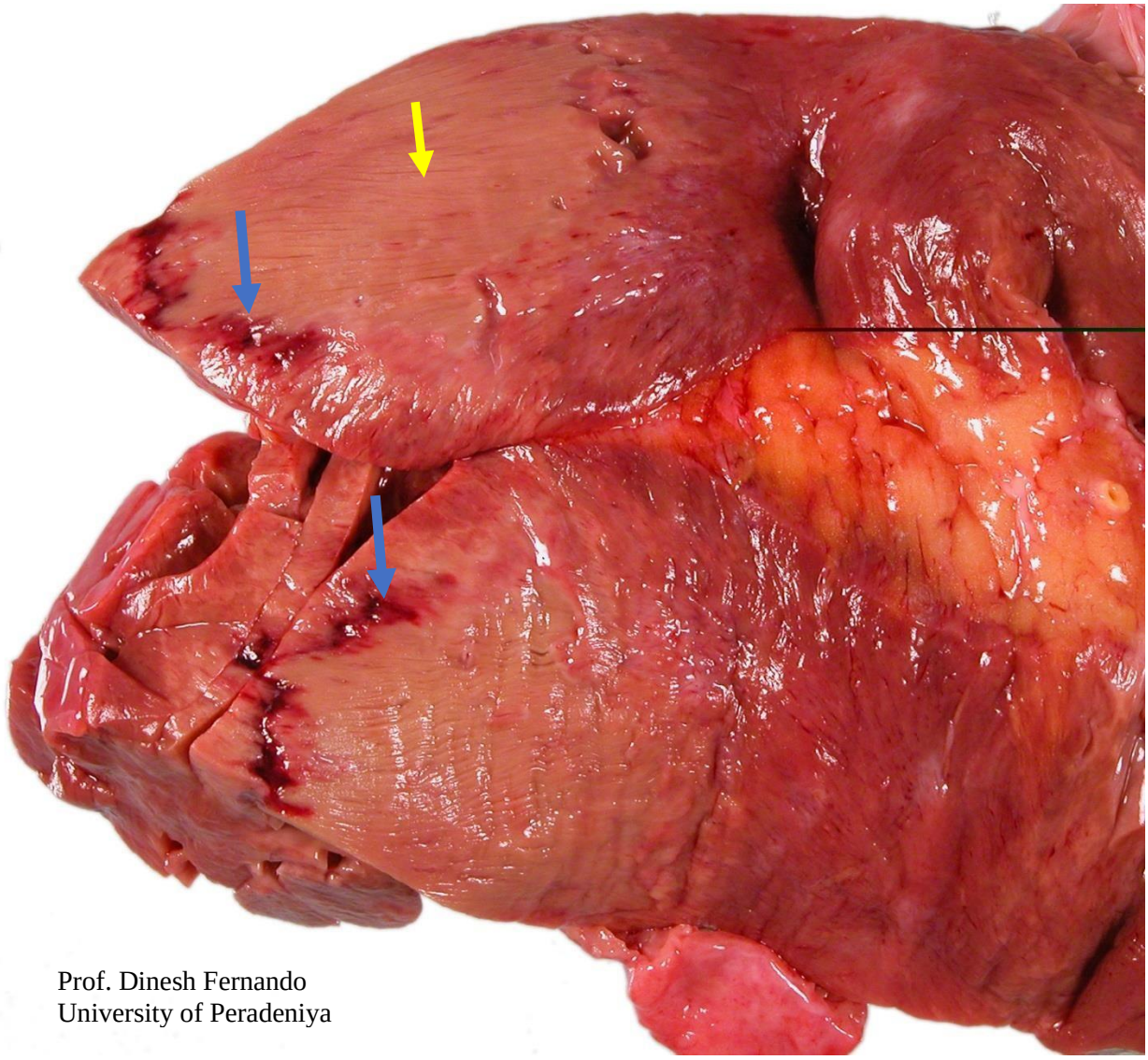
Figure 3: Myocardial infarction 24 to 48 hours

Note the fragmented myocytes. Karyorrhectic debris are seen as densely basophilic granules (yellow arrows).

Note the contraction bands in remaining parts of myocytes (blue arrows)

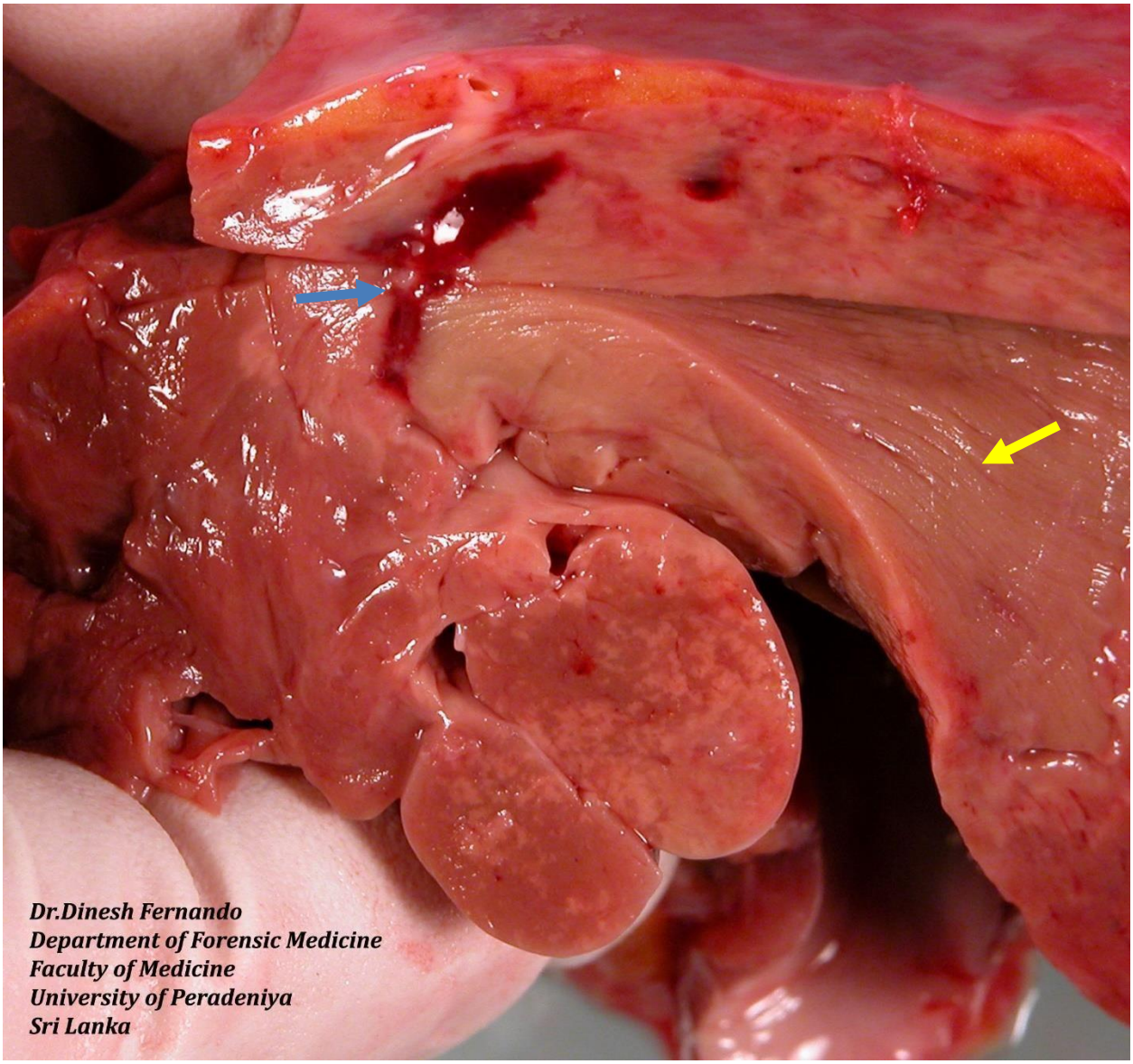
48 to 72 hours

Macroscopy: The infracted area become pale with hyperaemic borders



Prof. Dinesh Fernando
University of Peradeniya

(a)



(b)

Figure 4(a,b): Myocardial Infarction 48-72 hours Infarcted area which had become pale (yellow arrow) with hyperaemic borders (blue arrow)

Microscopy

The main feature is necrotic changes in cells, characterized by cytoplasmic degeneration and fragmentation. Prevalence of these necrotic changes decreases with increasing age of the infarct. Neutrophils start invading the degenerating myocardial fibres.

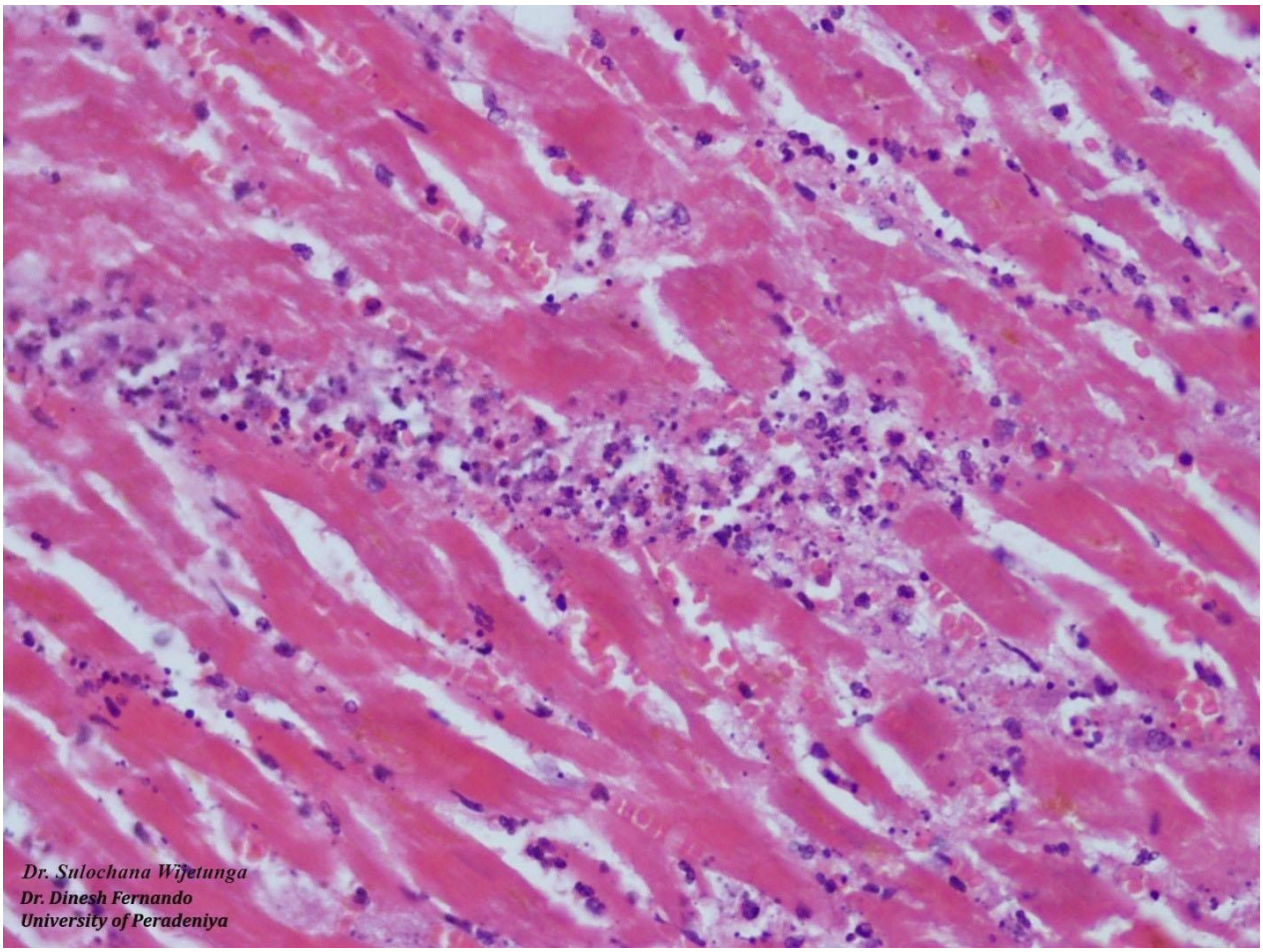


Figure 5: Myocardial infarction 48 to 72 hours. Fragmented myocytes are getting infiltrated by neutrophils. Still the neutrophil infiltration is not heavy. Karyorrhectic debris are still abundant.

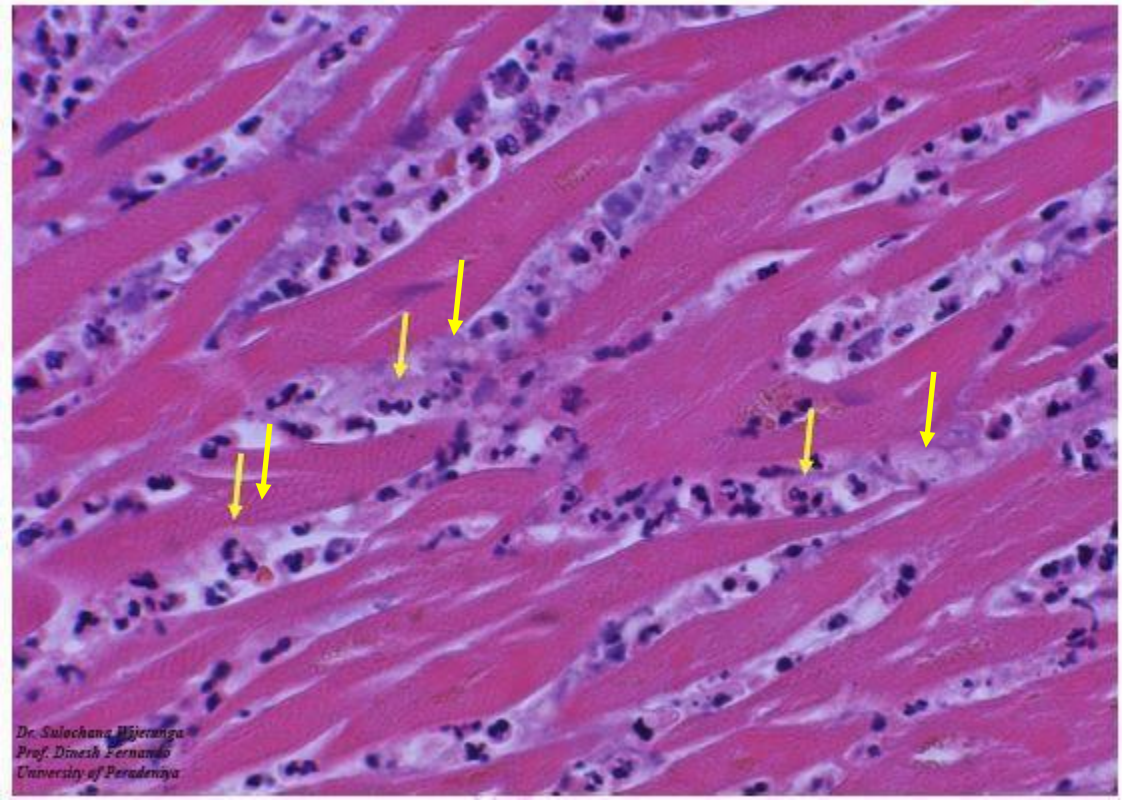
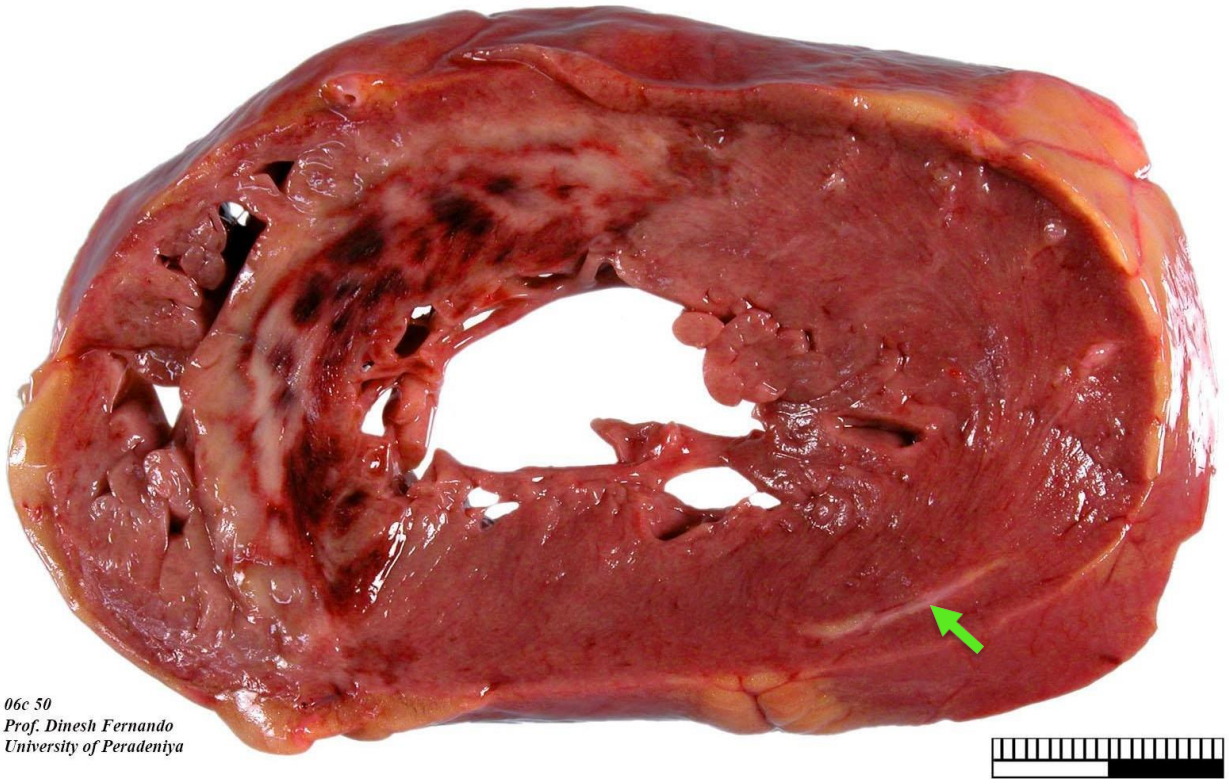


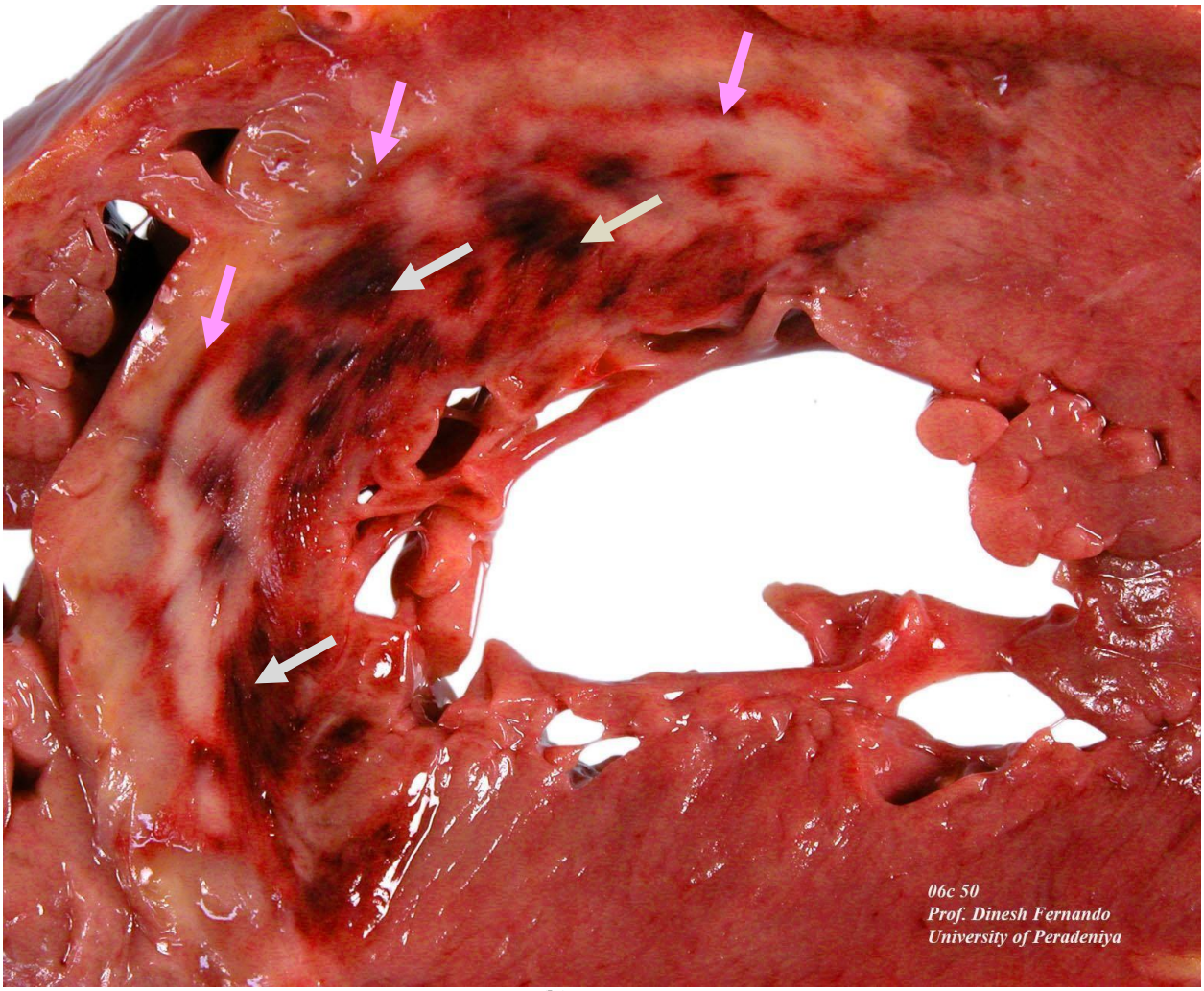
Figure 6: Myocardial infarction 48 to 72 hours (higher power). Dead myocytes are getting infiltrated by neutrophils (arrows). Neutrophils can be identified by their lobulated nuclei.

3 to 7 days

Macroscopy: The pale region gradually become yellow due to neutrophil action in dead myocytes and the hyperaemia in the borders become more intense giving rise to a 'tigroid' appearance.



(a)



(b)

Figure 7(a,b): The 'Tigroid' appearance caused by the streaks of red (due to dilated vascular channels and inter fibre haemorrhage) (pink arrows) between the yellow infarcted areas seen around 3-4 days gradually enlarges and by about the 10th day the infarct becomes maximally yellow with marked hyperaemia seen as reddish blotches on a yellow background transforming into a "leopards rosette" like appearance (grey arrows). Fibrosis is depicted by a green arrow.

Microscopy:

The main feature is neutrophils invading and digesting the necrotic myocardial fibres. There are basophilic neutrophils debris in the interstitium. Neutrophil infiltration persists until about 6th or 7th day and then gradually declines.

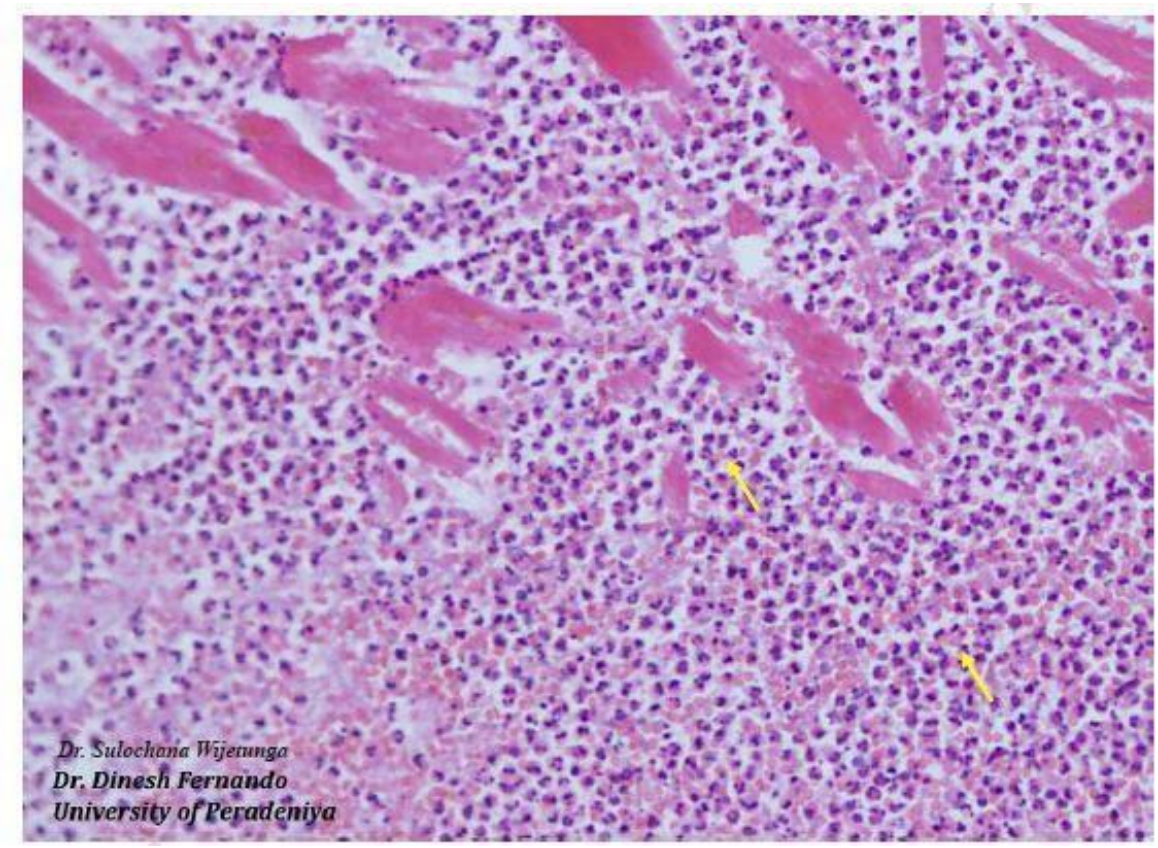


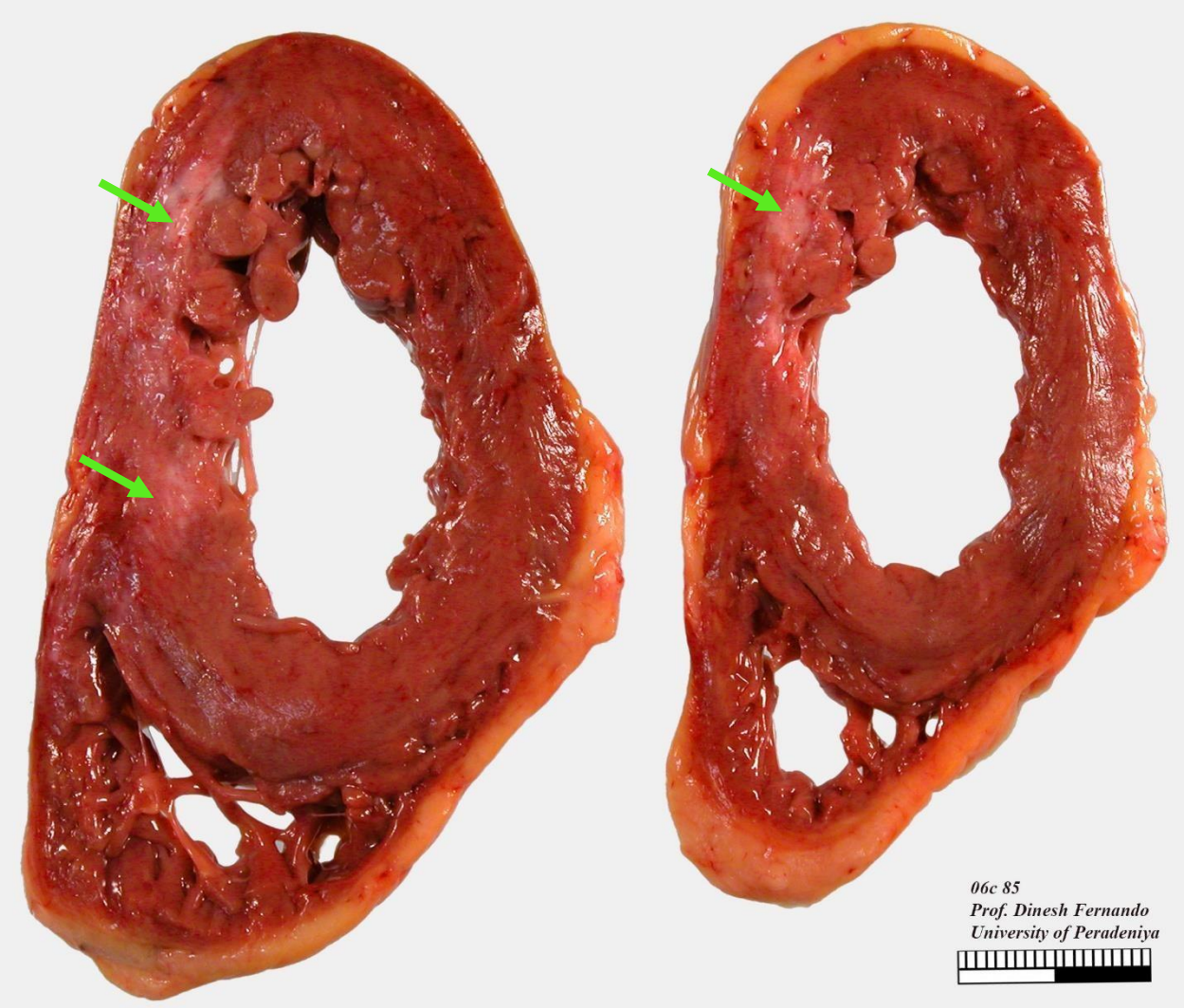
Figure 8: Myocardial infarction – about 3 to 5 days old

Myocardial fibres are more degenerated and the neutrophil infiltration is dense (arrows)

7th day onwards

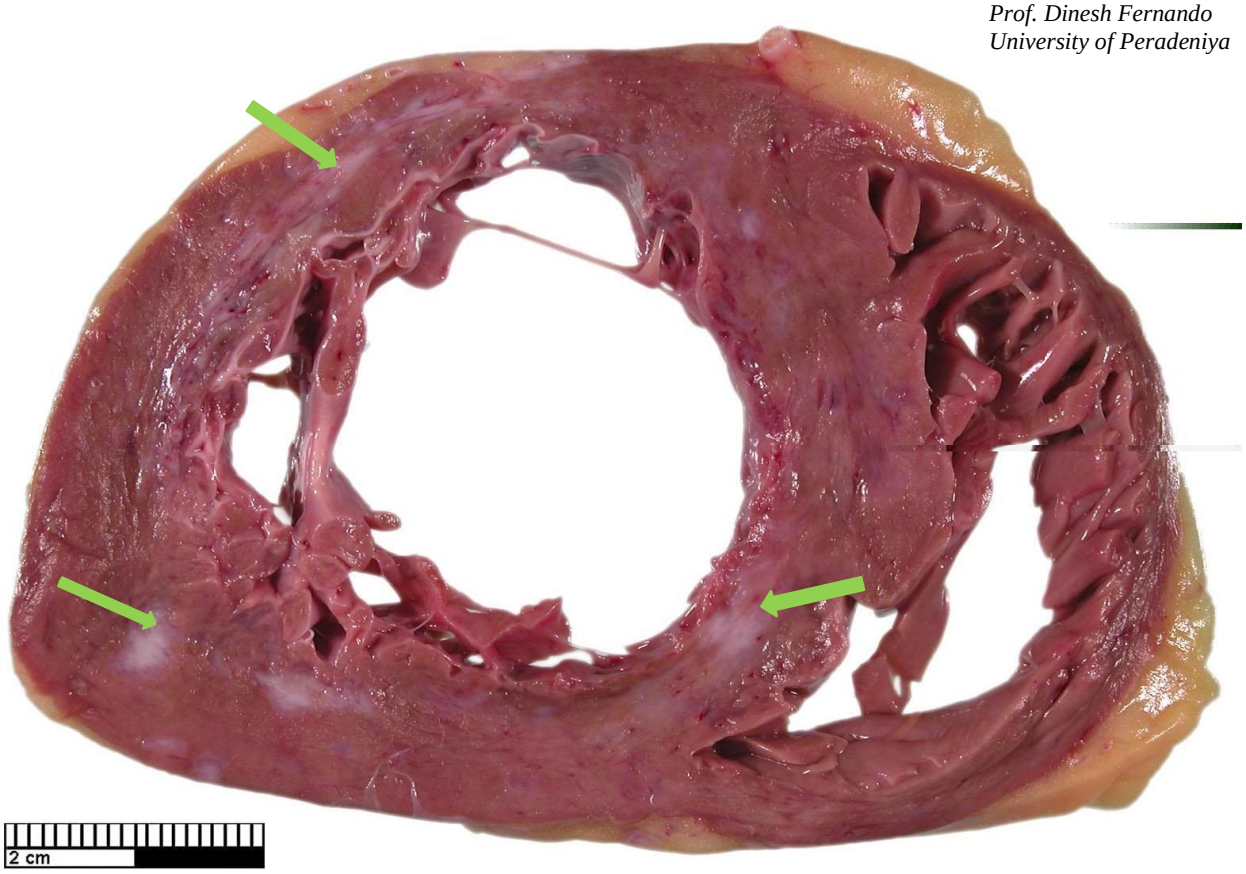
Macroscopy:

With increasing collagen accumulation, the infracted area gradually become whitish and ultimately the infracted region is seen as a whitish scar – old infarct.

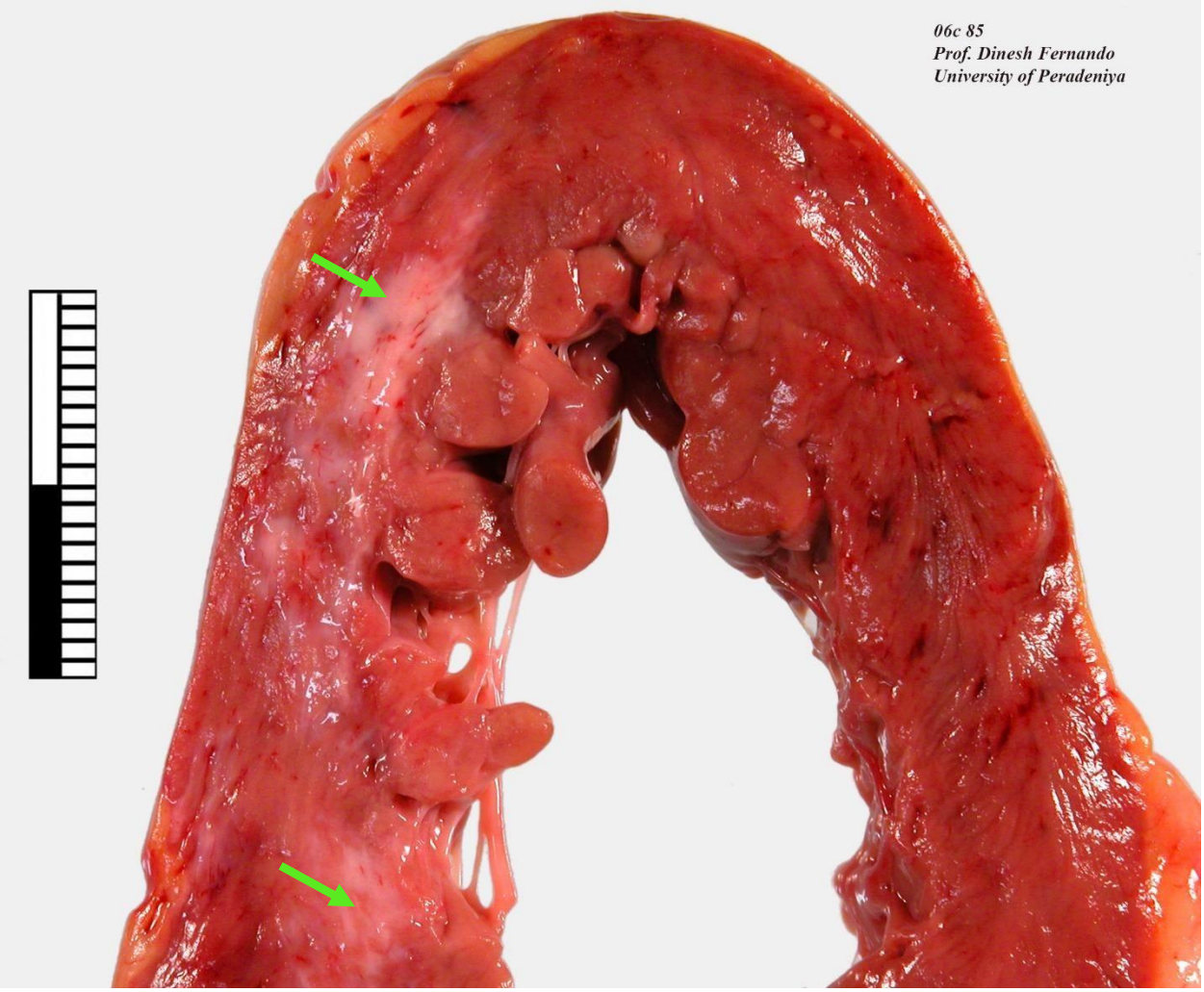


(a)

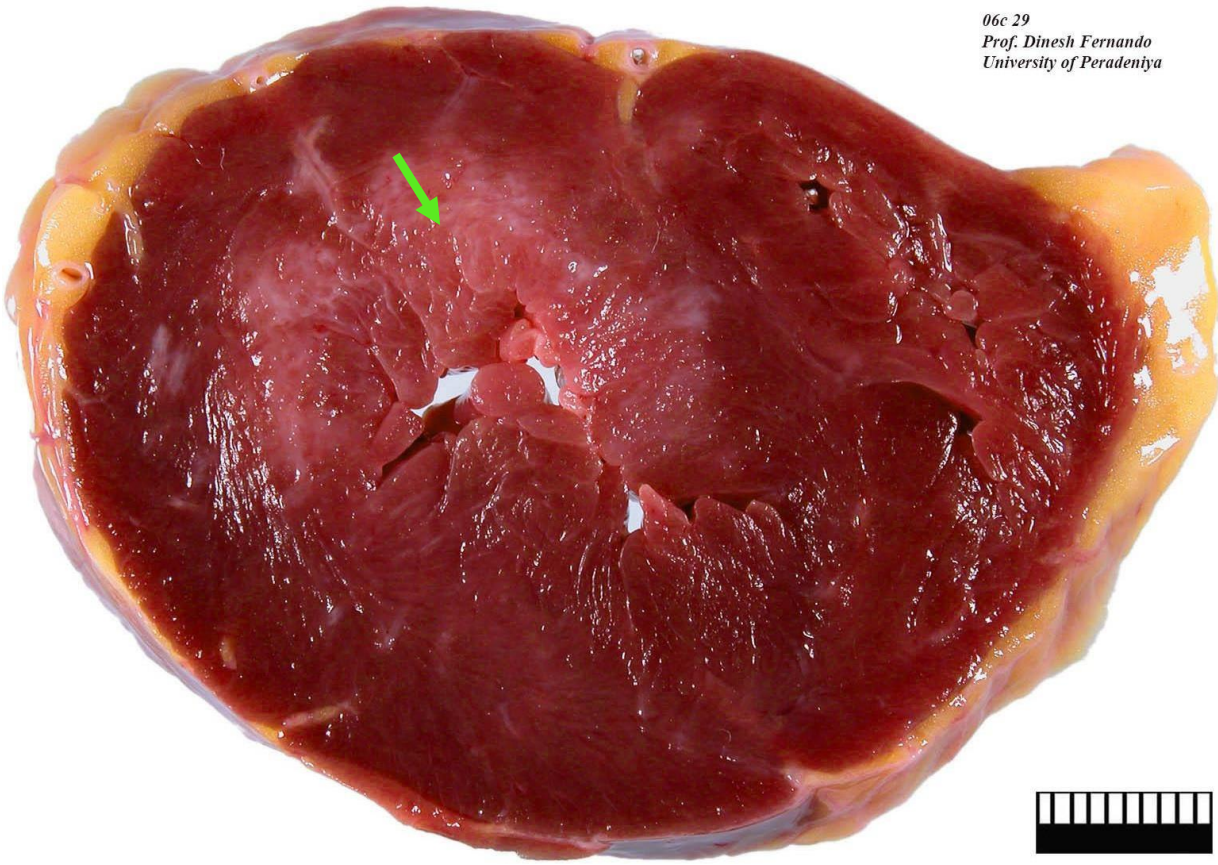
Prof. Dinesh Fernando
University of Peradeniya



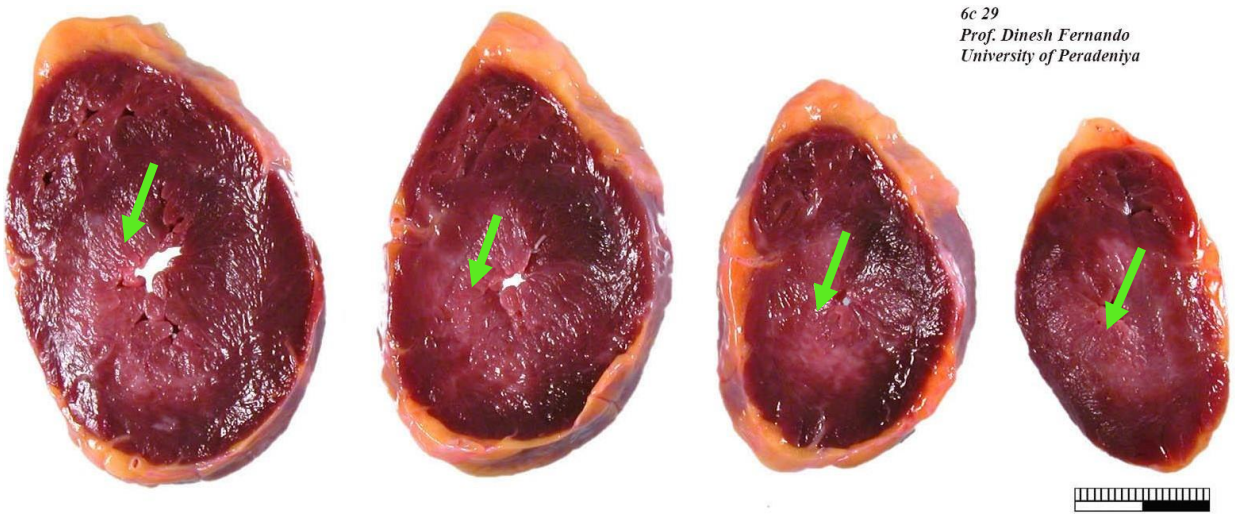
(b)



(c)



(d)



(e)

Figure 9(a to e): Advanced Fibrosis over several weeks (green arrows)

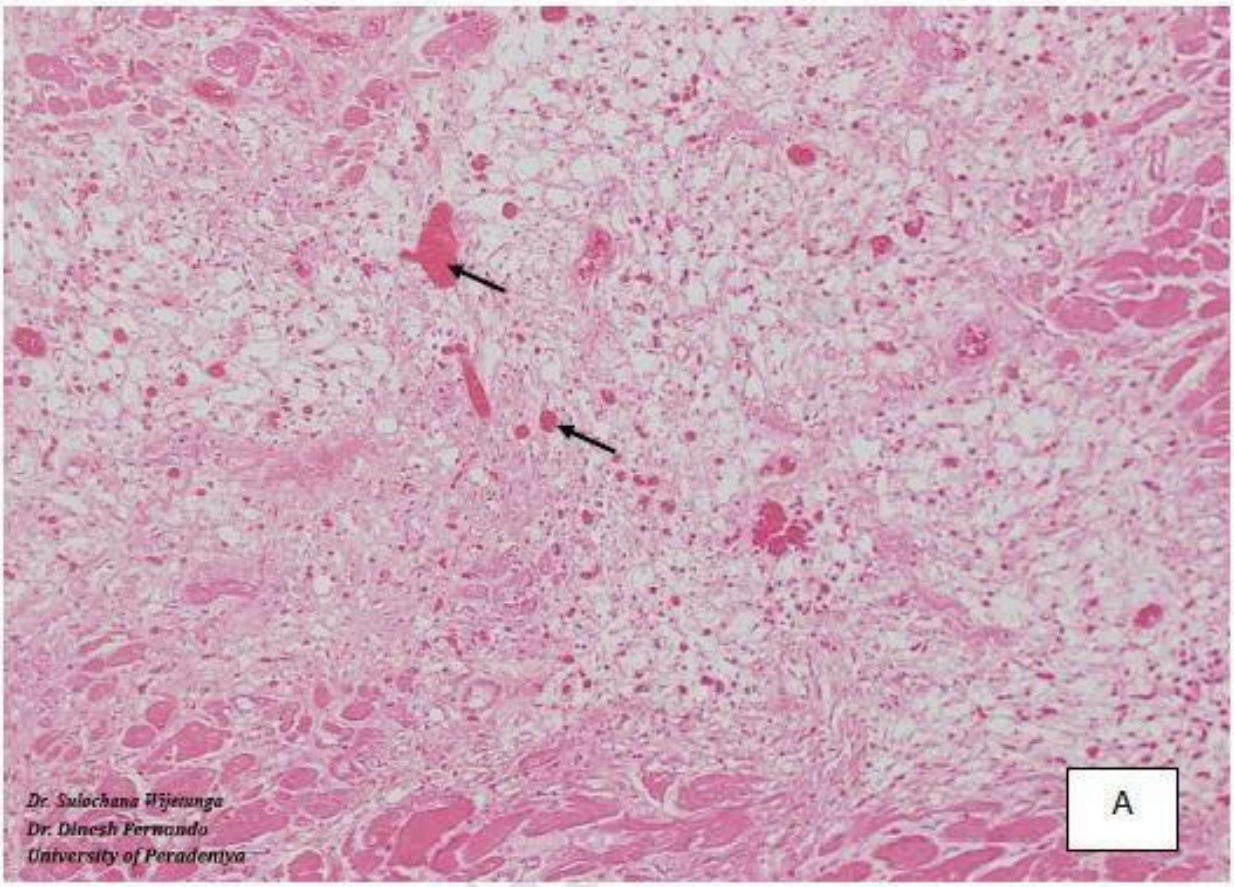
Microscopy:

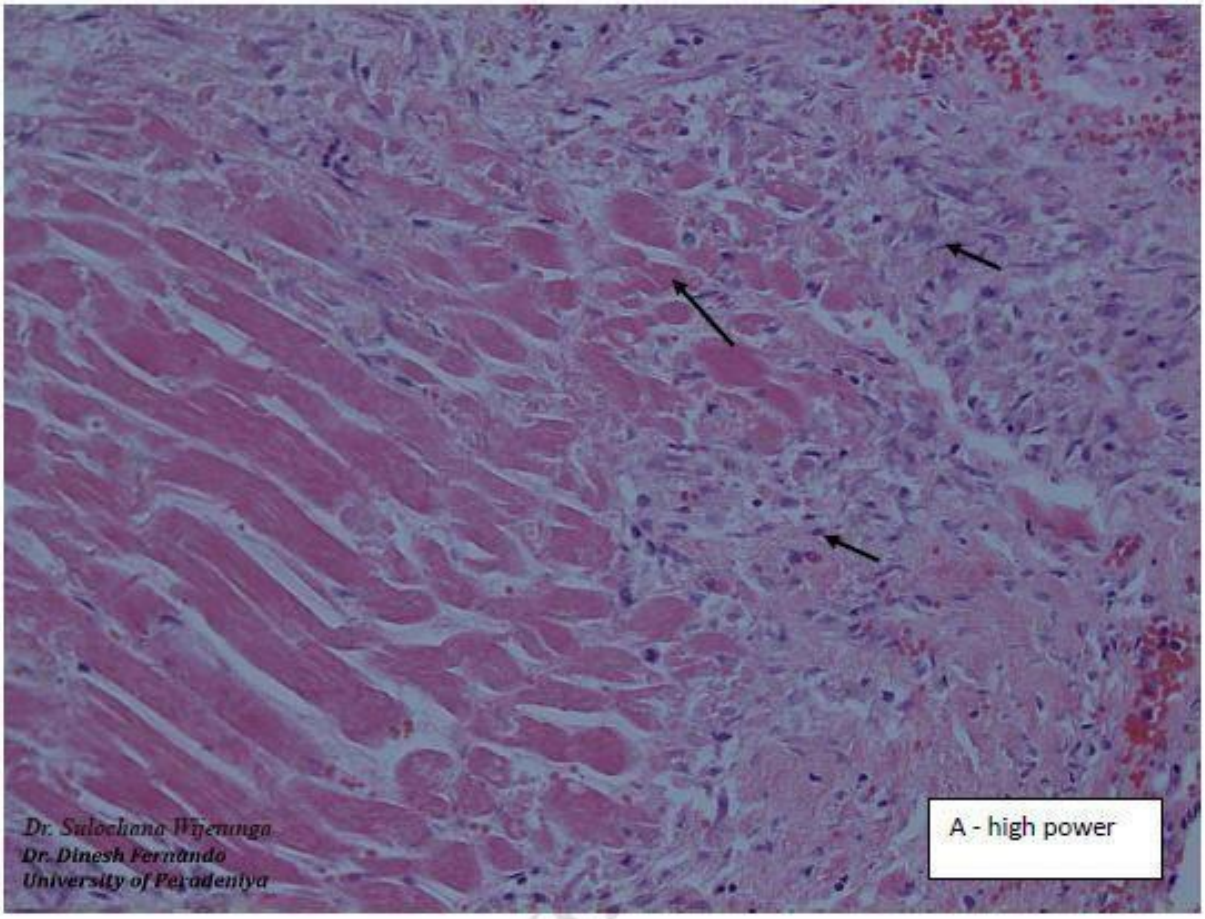
In the second week macrophages and other mononuclear inflammatory cells predominate. The purpose of macrophages is scavenging and secretion of cytokines to lay the background for healing process.

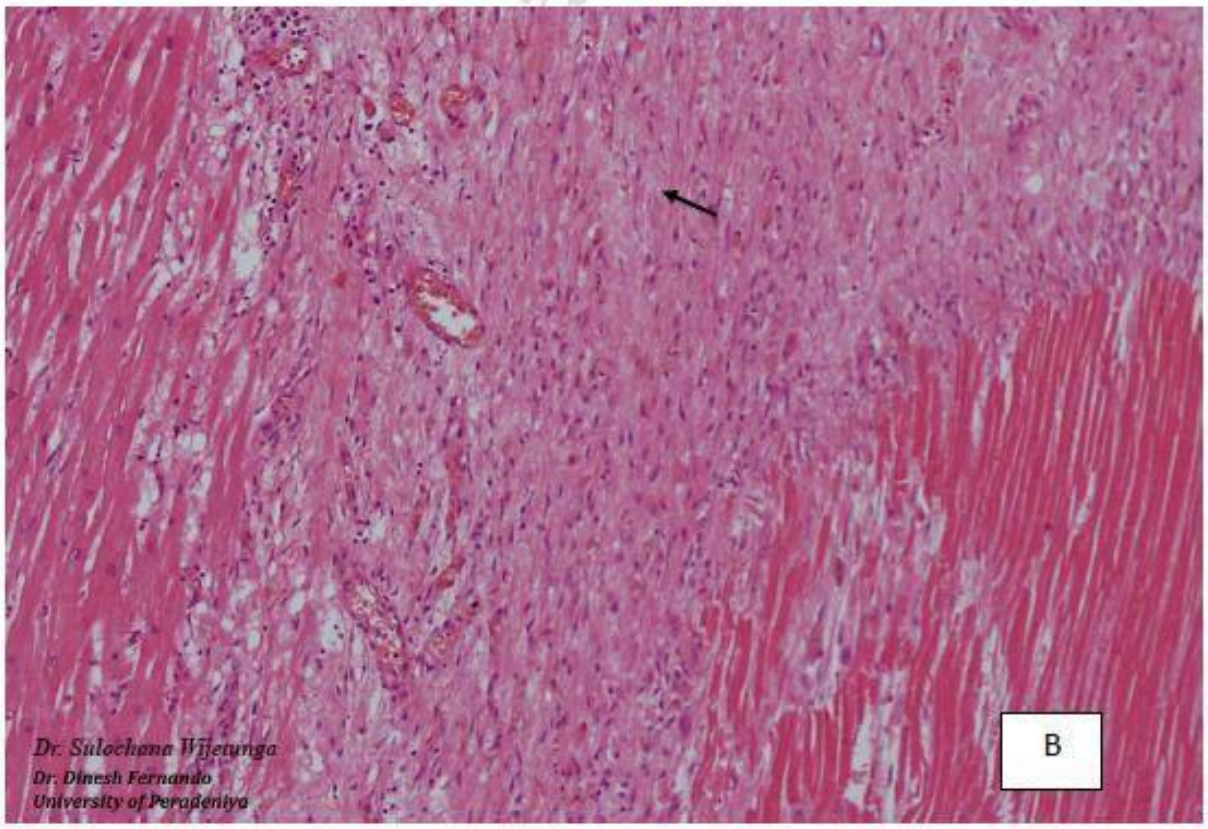
By about the 10th day the necrotic changes become well developed with granulation tissue formation in the margin.

Granulation tissue formation starts from the 7th day onwards and become the main feature in the 3rd week. This begins from the edges of the infarct. Granulation tissue is characterized by numerous capillaries and proliferating fibroblasts. These fibroblasts synthesize and lay down collagen. This is the repair process of a myocardial infarction, i.e since myocardial cells are permanent cells repair of an infarction is done solely by fibrous tissue formation (scar).

With advancing age of the infarct there is progressive accumulation of collagen with decreasing vascular and fibroblast density. This takes place over several weeks and ultimately the infracted area gets replaced by an acellular collagen scar. Although the time taken to produce this scar is quite variable, roughly it takes about 7 weeks. Once the scar tissue is formed the infarction cannot be dated any longer.


Dr. Sulochana Wijesinga
Dr. Dinesh Fernando
University of Peradeniya
A


Dr. Sulochana Wijeratnga
Dr. Dinesh Fernando
University of Peradeniya
A - high power


Dr. Sulochana Wijetunga
Dr. Dinesh Fernando
University of Peradeniya
B

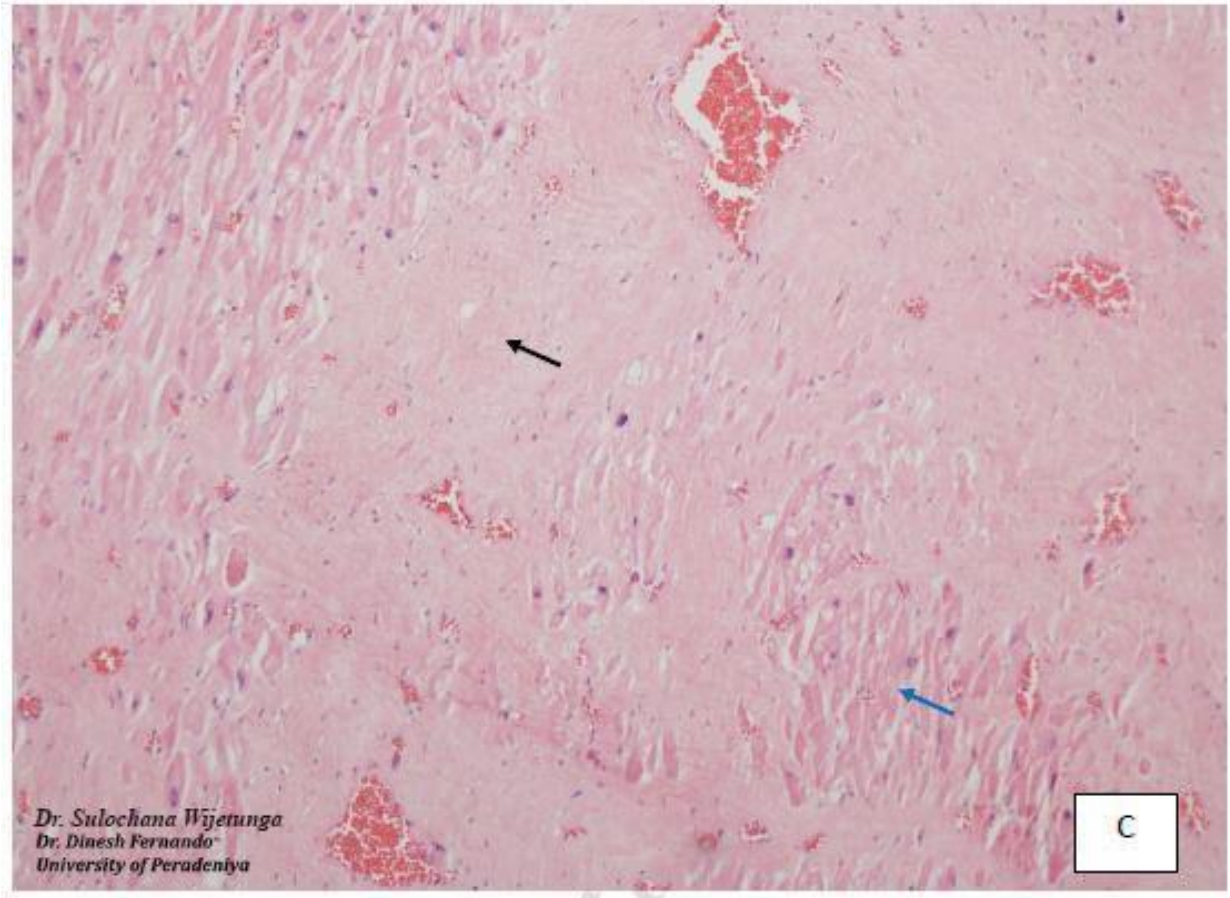


Figure 10(A, B & C): Scar tissue formation in a myocardial infarction (repaired by organization)

A) Early phase – granulation tissue formation. Note the high vascularity. Higher power view show higher cellularity due to fibroblasts (arrows). (fibroblast synthesize and lay down collagen)

B) Intermediate - Vascularity and cellularity have decreased and more collagen has been laid down. Collagen is seen as eosinophilic acellular material (arrow).

C) Advanced scar – granulation tissue is replaced by masses of acellular collagen (black arrow). Residual viable myocardial fibres are also present (blue arrow)