Hepatic Artery Ligation - Myths Disproved - An Experimental Study in Dogs

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The usual myths surrounding the procedure of selective hepatic artery ligation (SHAL) are hepatic necrosis, failure and high incidence of septic complications resulting in increased morbidity and mortality. We conducted an experimental study in twelve healthy mongrel dogs to determine the postoperative sequalae and to ascertain the validity of traditional concepts/ myths about SHAL. Lobar branch of the hepatic artery to left lateral lobe of liver was ligated in all the dogs and postoperative outcome was studied for three months. Indices like postoperative recovery, serial enzymatic changes and mortality were our guiding principles to determine the pathophysiological derangements and improvements after SHAL. Serial autopsies after sacrificing the animals were performed to determine the gross abnormalities in the affected lobe of liver. All the dogs had smooth postoperative recovery without any gross abnormalities in the liver, septic complications or mortality. However, significant transient changes in serum enzyme levels during early postoperative period were detected. There was no evidence of permanent hepatic dysfunction/ damage after SHAL. This study has disproved many myths surrounding the procedure of selective hepatic artery ligation. Therefore, we recommend its use as a primary means of securing haemostasis in most of the major liver injuries. It may prove to be a simple life saving procedure in such injuries without increased morbidity and mortality, especially at peripheral hospitals where facilities are deficient and experienced surgeons are usually not available.
Key words: Hepatic Artery Ligation

Traditional teaching in surgery has been that hepatic artery or its lobar branches should not be ligated deliberately because this procedure is associated with high morbidity and mortality. This concept was largely based on experimental studies on dogs[1,2] and a cumulative review of accidental ligation of hepatic artery in humans[3]. Later, on the basis of extensive studies [4,5,6] the validity of this concept was refuted. Madding in 1954 suggested for the first time the use of SHAL in hepatic trauma as a means of initial haemostasis. Due to variable subsequent experience [7,8,9,10,11] and continuing fear of hepatic necrosis and failure many surgeons still have misgivings regarding safety of the procedure[12].

In clinical studies of major hepatic trauma many additional factors like severe shock, concomitant multi-organ / system injuries, sepsis and liver parenchymal damage also adversely affect the outcome. In the presence of these factors high morbidity and mortality is usually wrongly attributed to the procedure of SHAL. Therefore, we conducted an experimental study of SHAL on dogs to determine the detailed postligational pathophysiological consequences of the procedure in the absence of these adverse factors. The objectives of the study were:to ascertain the short and long term sequalae of SHAL when carried out as an isolated procedure to investigate the validity of traditional alarming concepts about SHAL

Materials And Methods:
This study was conducted at the Animal Experimental Laboratory of Postgraduate Medical Institute, Lahore. The SHAL was performed in twelve healthy adult mongrel dogs of either sex. The dogs were randomly selected and divided into two equal groups. Group A dogs were observed till the death of animals or sacrifice according to the protocol on postoperative days 3, 7, 15, 30, 60 and 75. Group B dogs were observed till death of the animals or sacrifice on 90th post operative day. Female pregnant dogs or the animals which died due to causes other than SHAL were excluded from the study. Two doses of first generation cephalosporin antibiotic, 12 and 1/2 hours, before surgery were given intramuscularly. The dogs were anaesthetised with intravenous administration of 5% solution of Thiopentone Sodium and it was maintained with intravenous repeated small doses of 2.5% solution of the same drug. In all the dogs lobar branch of hepatic artery supplying the left lateral lobe of liver was identified, dissected and ligated in continuity with black silk as close to the entry of vessel into the liver lobe as possible. Animals were not fed till the recovery of bowel function. Antibiotics were continued postoperatively for three days. Postoperative outcome including complications, mortality and their relationship to SHAL were observed closely. Serial biochemical studies were performed at Pathology Department, Postgraduate Medical Institute, Lahore. At the time of sacrifice, after in situ examination, the whole liver was removed for further studies.

Results:
Postoperative outcome after SHAL was smooth and there were no operative or postoperative mortalities. However, serial estimation of liver function tests revealed marked rise in serum levels of transaminases (SGOT and SGPT) during early postoperative period. These changes reached statistically significant levels in the first week with a peak rise during initial 3 to 5 days. Serum enzyme changes returned to normal within 7 to 10 days and remained so

throughout rest of the observation period in all the dogs(FIG 1&2).

Fig.1 Mean changes in SGOT after SHAL in dogs

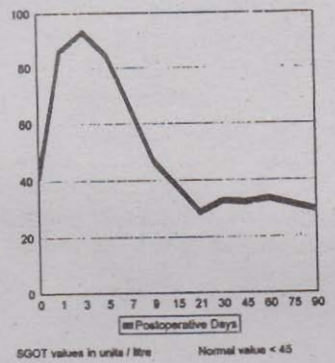
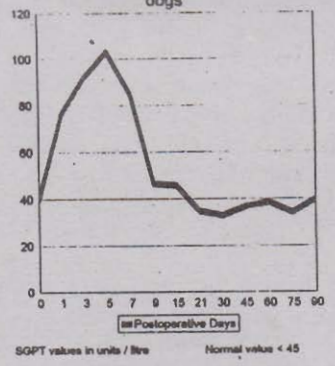
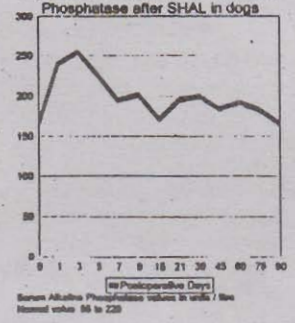


Fig.2 Mean changes in SGPT after SHAL in dogs



Similar changes in serum levels of alkaline phosphatase and bilirubin were observed after SHAL but these did not rise to statistically significant level when compared with the upper normal valuesFig(3&4).

Fig.3 Mean changes in Serum Alkaline Phosphatase after SHAL in dogs



Serum levels of total proteins and albumin remained within normal limits throughout the postoperative and follow up periods in all the dogs Fig (5&6).

At the time of sacrifice both in situ examination and serial sectioning of specimens of liver did not reveal any hepatic necrosis, intra or perihepatic sepsis, nodularity, atrophy or scarring.

Fig.4 Mean changes in Serum Bilirubin after SHAL in dogs

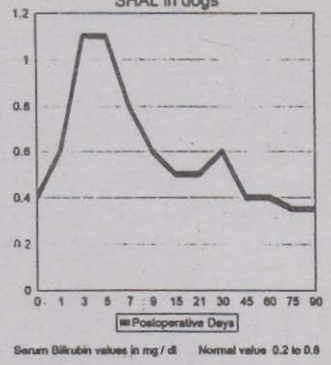


Fig.5 Changes in Serum Total Proteins after SHAL in dogs

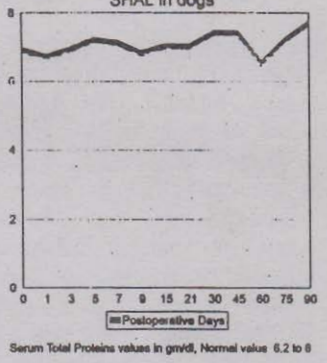
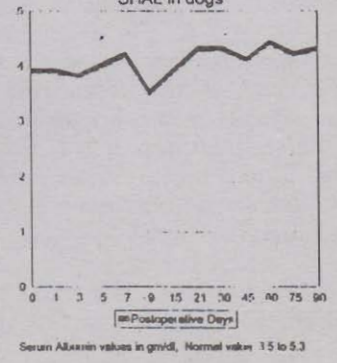


Fig.6 Mean changes in Serum Albumin after SHAL in dogs



Discussion:

SHAL does not result in permanent hepatic dysfunction or damage[13,15]. However, traditional view in surgery importunates that hepatic artery ligation is a dangerous procedure and is invariably followed by a lethal outcome. This view is largely based on the: experimental studies of pre-antibiotic era on dogs in which death was invariably followed by spongy liver necrosis due to millions of anaerobic organisms, normally residing in liver and portal blood of dogs, and the contention that the hepatic arteries are end arteries.

Markowitz in a series of experiments on dogs revealed that the spongy necrosis of liver could be prevented by giving penicillin to animals after ligating hepatic artery or its lobar branch[13,14]. Role of anaerobic micro-organisms in septic hepatic necrosis and preventive effect of antibiotics was reaffirmed subsequently by other workers[15].

Changes in the serum levels of transaminases in our study suggest transient hepatic ischemia after SHAL. Such changes have also been described after haemorrhagic shock and experimental hepatic ischemia, suggesting microcirculatory readjustment in sinusoids after SHAL[16,17]. Moreover, the ischemic cells near the portal tracts rob most of the oxygen available in the portal vein blood and the remaining cells in the centrilobular area get relatively more deoxygenated blood[18]. All these changes are transient till the opening up of new collaterals. Many studies have shown both intra and extra hepatic collateral pathways to the liver after hepatic artery ligation. These collaterals are not functional under normal circumstances and open up only in response to ischemic threat to the liver. These collaterals usually become functional within 4 to 14 hours of ligation of hepatic artery or its lobar branch, refuting the traditional concept that hepatic arteries are end arteries[19, 20].

Transient rise in serum alkaline phosphatase and serum bilirubin observed in our study have also been described by Walt[21]. The plausible explanation of this could be the retention theory according to which transient ischemia after SHAL results in intrahepatic cholestasis due to swelling of the hepatocytes[22, 23]. Minimal changes in serum protein levels suggest that synthetic function of the liver is minimally affected after SHAL[24]. Late sequalae of hepatic ischemia like persistent rise in serum transaminases, fibrosis, atrophy and cirrhosis were not observed in our study even in dogs which were kept under observation for three months after SHAL. This accords well with other studies in which embolization of hepatic artery in dogs was performed[25]. Moreover inspite of certain adverse factors which operate in dogs and not in human beings, all the dogs generally tolerated selective hepatic artery ligation extremely well. These adverse factors are:

The capacity to form collaterals and intercallary vessels in and around the liver is meagre in lower animals than humans[20].

The quiescent oxygen saturation of portal blood is lower in dogs and rats than humans[27].

The anatomical relationship and arterial supply of the neighbouring structures in laboratory animals is different from humans which can provide rich collateral supply in humans after SHAL[28]. Moreover, portal bacteremia is common in most laboratory animals whereas both human liver and portal blood are sterile[29].

Therefore, the extrapolation of animal studies of pre-antibiotic era to humans does not appear to be relevant any longer. In our study, absence of gross evidence of fibrosis, atrophy and cirrhosis and biochemical derangements after SHAL were suggestive of transient mild ischemic damage to the liver without any lethal outcome. It has disproved many myths like hepatic necrosis, high incidence septic complications, hepatic failure and increased mortality due to SHAL.

We conclude that SHAL is a safe procedure with predictable sequalae. Therefore, we strongly recommend its use as a primary method of securing haemostasis in all major liver injuries resulting in profuse arterial bleeding. Under local conditions where specialised trauma centres are not available and facilities for rapid transportation, massive blood transfusion and ancillary services like intensive care are not always available, it may prove to be a simple, quick and effective method of achieving haemostasis in most of the major liver injuries.

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