

PULMONARY EMBOLISM EXPERIMENTAL STUDY ON EMBOLECTOMY

BY

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ABSTRACT

Pulmonary embolism has been thought as a relatively rare disease in Japan. In the recent reports, however, the rate of increase of this disease is almost similar to that in the United States.

We reported already about the experimental studies on pulmonary embolism by our original method and studied the roentgenographic changes in relation to the pathohistological findings. In this paper we will report on the experimental studies on embolectomy in the pulmonary artery, especially on the limitation of the effectiveness of this procedure.

A total of 45 dogs were used for this study. The embolectomy and thrombectomy by thoracotomy were performed after 1, 2, 3 and 4 days and 1 week following the insertion of the Laminaria-embolus. During thoracotomy the pressure of the pulmonary artery was measured before and after embolectomy. X-rays of the chest were taken after 1 and 3 days and 1 week following embolectomy and we made pathohistological examinations of the resected lungs.

We were not able to find any literature on the limitation of the effectiveness of embolectomy in the pulmonary artery.

We suppose from these findings that embolectomy should be done 1 or 2 days after the pulmonary embolism occurs and in the early stage when the changes caused by pulmonary embolism are still reversible.

Pulmonary embolism has been thought as being a relatively rare disease in Japan. In the recent reports, however, although the incidence of this disease is as yet low, the rate of increase is almost similar to that⁵⁷⁾ in the United States^{3,5,7,12,13,20,21,32,37,39,55)} and Europe^{19,42)}.

For surgical treatment of pulmonary embolism, in 1908 Trendelenburg proposed embolectomy⁵⁶⁾, and the first successful operation was recorded by Kirschner in 1924^{16,31,50)}. Since 1961^{11,48)} several successful cases of pulmonary embolectomy using the cardio-pulmonary bypass have been reported^{4,14,41,42,44,46,53,59,60,64)}. But patients with acute pulmonary embolism are often seriously ill or even moribund and the mortality of this operation

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is nearly 70% in the United States¹⁰).

We reported already about the experimental studies on pulmonary embolism by our original method using the Laminaria-embolus and studied the roentgenographic changes in relation to the pathohistological findings⁸⁴. In this paper we will report on the experimental studies on embolectomy in the pulmonary artery, especially on the limitation of the effectiveness of this procedure.

METHOD

The Laminaria-embolus, the center of which was marked with a piece of fuse-wire, and a fine nylon thread, which was connected to the embolus, were used for this study in 45 unselected dogs. This Laminaria-embolus could be easily inserted into the external jugular vein through a simple incision of the vein. The embolus reached the right ventricle by pushing it with Nelaton's catheter and easily entered the pulmonary artery with the blood stream. Then we controlled the position of the embolus by the nylon thread under x-ray illumination and fixed the end of the thread to the jugular vein. By this technique the pulmonary artery was completely occluded at the optimal point on either side by the swollen Laminaria-embolus, the x-rays of the chest showing the position of the Laminaria-embolus quite clearly (Fig. 1).

The embolectomy and thrombectomy by thoracotomy were performed after 1, 2, 3 and 4 days and 1 week following the insertion of the Laminaria-embolus. In the case where the pulmonary embolism occurred at the root of the pulmonary artery the dogs died of course in several hours, but if the embolus remained in the lobular artery the dogs survived. During thoracotomy the pressure of the pulmonary artery was measured before and after embolectomy. X-rays of the chest were taken after 1 and 3 days and 1 week following embolectomy and we made pathohistological examinations of the resected lungs.

RESULTS

A total of 45 dogs were used for this study. When pulmonary embolism occurred, x-ray showed no shadow of the vasculature of the involved lung⁶¹. This finding appeared in 3-6 hours following the occlusion of the pulmonary artery. Then a homogenous shadow which is usually called "atelectasis" appeared 1 or 3 days following the insertion of the embolus⁶³. But if embolectomy was performed within 1 or 2 days after the occlusion of the pulmonary artery, the homogenous shadow disappeared rapidly and the x-ray picture taken 1 week after became normal (Figs. 2 and 3).

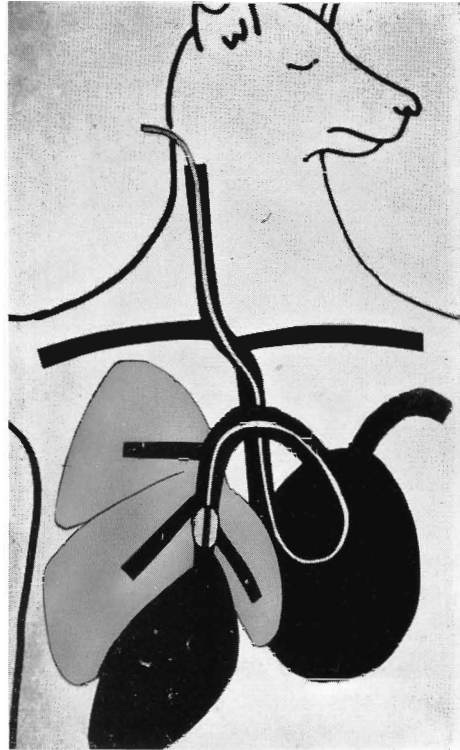


Fig. 1-a. Schema of introduction of the Laminaria-embolus.

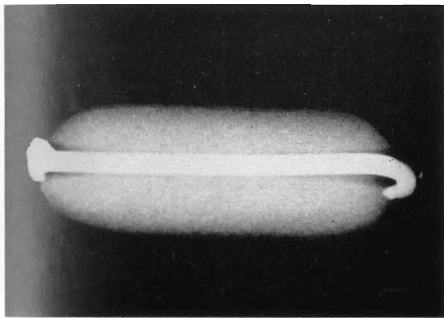


Fig. 1-b. Roentgenogram of the Laminaria-embolus.

Even if embolectomy was not performed, roentgenogram showed a decrease in the homogenous shadow one week after the pulmonary embolism as we have ever reported (Fig. 4). On this occasion, the bronchial artery played an important role in the recovery of these changes, and the marked dilatation shown by the arteriography of the bronchial artery suggests that it compensates for the loss of the blood supply from the pulmonary artery^{38,40,45,58} (Fig. 5). But it was demonstrated by the arteriogram of the

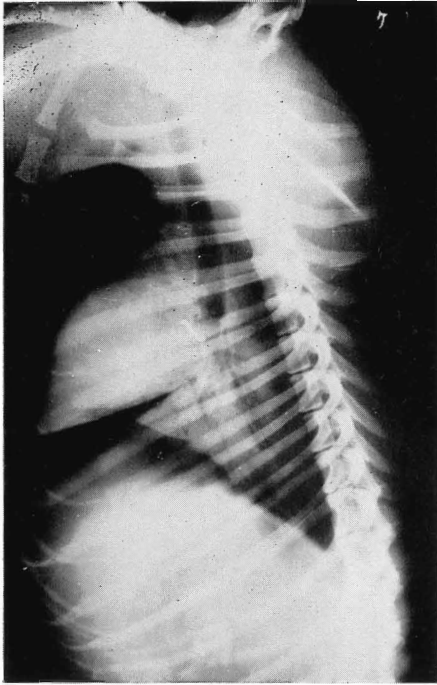


Fig. 2. Film taken 1 day after insertion of Laminaria-embolus. The homogenous shadow can be seen.

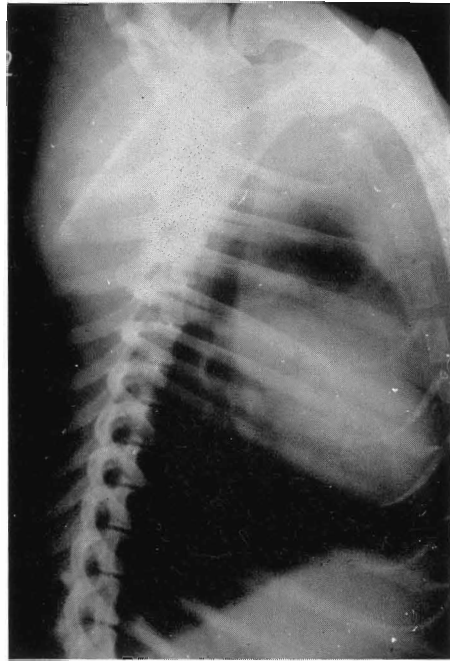


Fig. 3. Film taken 1 week after embolectomy.

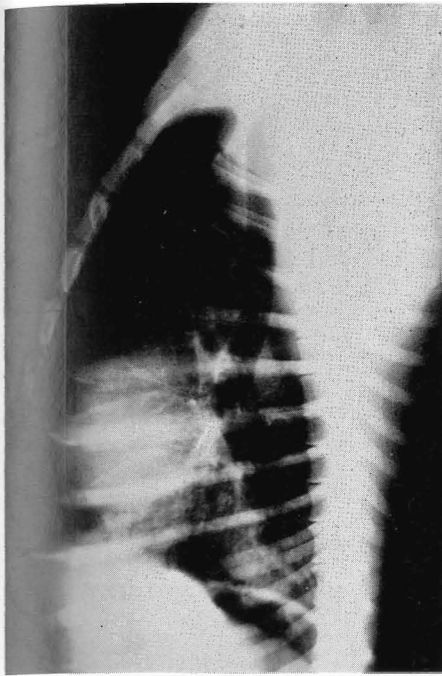


Fig. 4. Film taken 1 week after insertion of Laminaria-embolus. Homogenous shadow decreases.

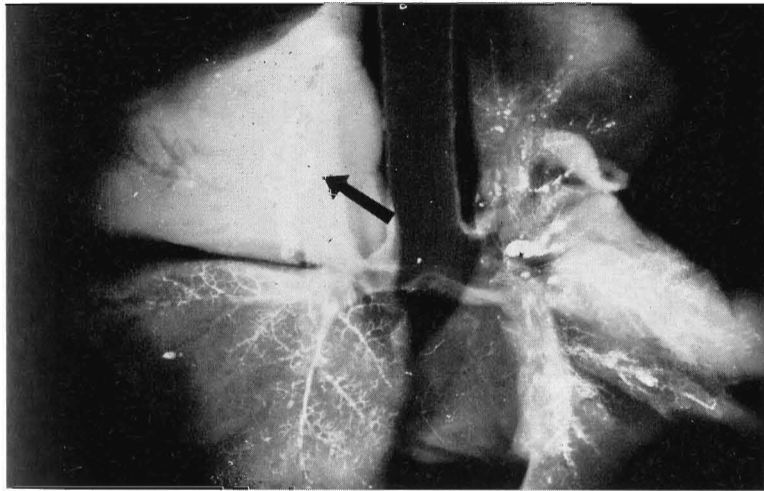


Fig. 5. Arteriogram of the bronchial arteries 1 week after insertion of Laminaria-embolus.

pulmonary artery that the recovery of the changes in the chest x-ray after embolectomy was due to the reopening of the pulmonary blood flow (Fig. 6). At autopsy one week after the pulmonary embolism, the affected area looked

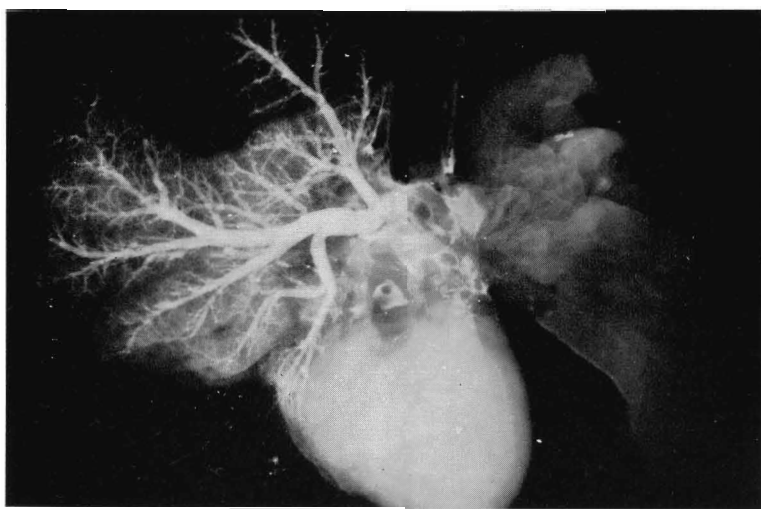


Fig. 6. Arteriogram of the pulmonary artery after embolectomy.



Fig. 7. Cut-surface of the resected lung at 1 week after insertion of Laminaria-embolus.

macroscopically dark and was hard in consistency, and showed complete hepatisation (Fig. 7). In the central part of the involved area, the medium size arteries were occluded. The intima was thickened and showed signs already of the beginning of organisation (Fig. 8). But in the case where embolectomy was performed in 1 or 2 days after pulmonary embolism, the affected area recovered macroscopically to quite normal as the other areas

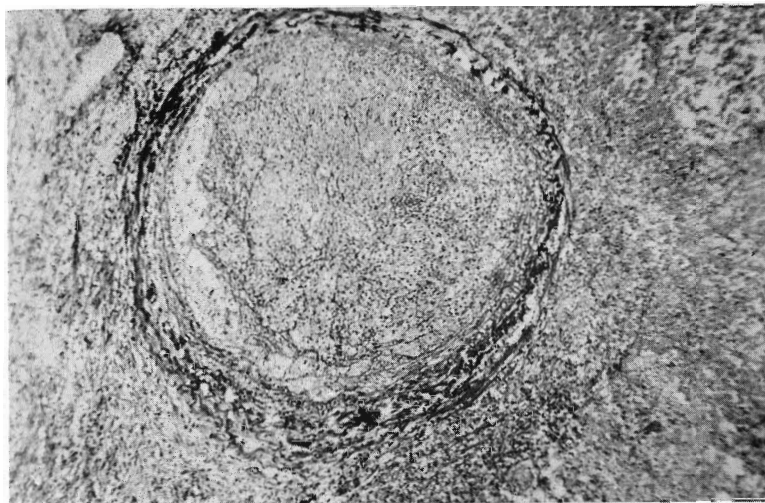


Fig. 8. Medium size artery show signs of the beginning of organisation.

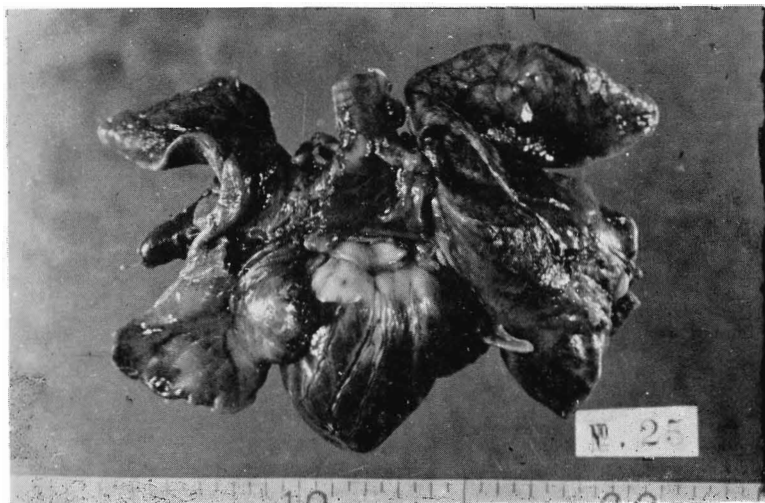


Fig. 9. Resected lung after embolectomy. The affected area recovered macroscopically to quite normal.

in the lung (Fig. 9). In the histological specimens the air volume in the alveolar cavities was normal and the pulmonary arteries were patent (Fig. 10).

We suppose that embolectomy should be done 1 or 2 days after the pulmonary embolism occurs, and even if we performed it at a later stage the changes in the arterial intima are irreversible and occlusion of the pulmonary artery occurs again. The blood pressure fell rapidly as soon as the

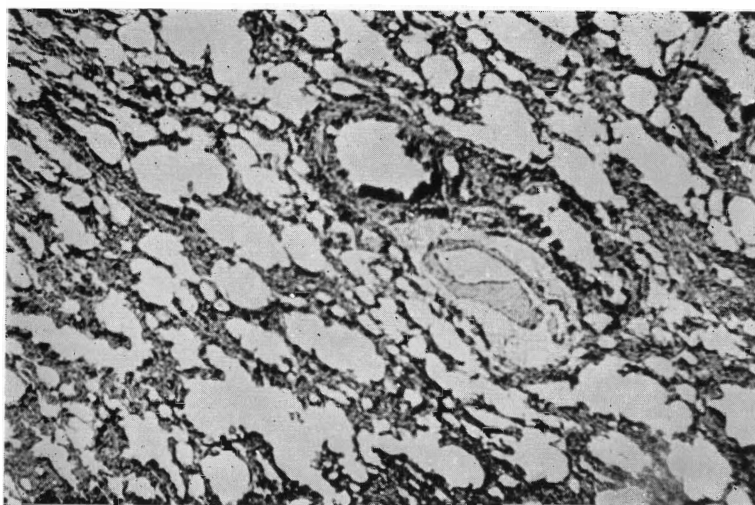


Fig. 10. Histological specimen of Fig. 9. The pulmonary arteries are patent.

pulmonary artery was occluded and the pressure in the pulmonary artery and right ventricle increased. If the dogs did not die the blood pressure

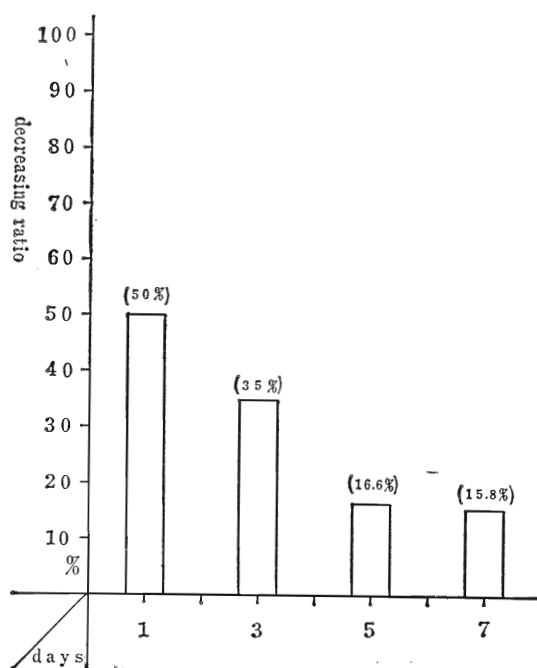


Fig. 11. The pressure in the pulmonary artery after embolectomy.

returned slowly to the normal level, and the pressure in the pulmonary artery decreased gradually but often it remained at a high level. We measured the pressure in the pulmonary artery before and after embolectomy at the same part of the root of the pulmonary artery. The return of the pressure was marked. After a period of 3 days following pulmonary embolism, the effectiveness of embolectomy was not seen (Fig. 11). We consider that these findings show the limitation of the effectiveness of embolectomy in the pulmonary artery.

DISCUSSION

As was described before, we succeeded in producing experimentally an ideal occlusion of the pulmonary artery at any part desired by our original method using the Laminaria-embolus and studied the changes in the x-rays of the chest in relation to the histological findings. This time using the same method we studied the effectiveness of embolectomy in the pulmonary artery roentgenographically and haemodynamically.

We suppose from these findings that embolectomy in the pulmonary artery must be performed at least within 1 or 2 days after pulmonary embolism. We were not able to find any literature on the limitation of the effectiveness of embolectomy in the pulmonary artery²⁴). We believe that the important points in the treatment of pulmonary embolism are as follows:

1) At the time of onset, it is necessary to treat acute cor pulmonale and shock, caused by the increased pressure in the pulmonary artery, neurogenic reflexes and secretion of serotonin, etc.^{1,26,28,29,35,36,62}) At this stage, it is questionable whether it is appropriate to do forced embolectomy. At the risk of shock even by using cardiopulmonary bypass embolectomy may be said to be dangerous. From the standpoint of blood flow in the pulmonary artery, it is considered that immediate death is caused by the obstruction of at least 60–70 per cent or more of the volume of blood flow⁴⁶). Furthermore, the cardio-pulmonary bypass may not be even ready immediately for use at this time⁶). Therefore, we believe that antishock therapy is the most important, and hyperbaric oxygen therapy^{10,25}) or hypothermic therapy may be useful in this stage.

2) Embolectomy may be necessary at least within 1 or 2 days after pulmonary embolism. Even though the recanalization in the thrombi may be a possible course in some cases, from the standpoint of pulmonary function complete thrombectomy is necessary in the early stage when the changes caused by pulmonary embolism are still reversible.

CONCLUSION

1) Laminaria-embolus is useful in studying experimental pulmonary embolism. We studied the effectiveness of embolectomy in dogs by this technique radiographically, pathohistologically and haemodynamically.

2) We believe that embolectomy must be performed within 1 or 2 days after pulmonary embolism, and after this period the changes in the affected lung will become irreversible and the recovery of the pulmonary function may be impossible.

3) We described the importance of embolectomy in pulmonary embolism and also the limitation of its effectiveness from the experimental study.

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