

PIONEERS AND PATHFINDERS

A Brief History of the Early Years of Blood Transfusion at the Mayo Clinic: The First Blood Bank in the United States (1935)

S. Breannan Moore

At the Mayo Clinic in 1914, Francis McGrath modified an existing aspiration-injection apparatus and adapted it for arm-to-arm blood transfusions. Separately, in 1919, both Pemberton and Sanford described in detail the Mayo Clinic experience with more than 1000 transfusions between January 1915 and January 1918. Most transfusions were by the indirect citrate method

from freshly drawn blood. In 1935, John Lundy established a bank of refrigerated blood for transfusions at Mayo Clinic and reported on the activity in that and subsequent years. The functioning clinical blood bank established by Lundy at Mayo Clinic predated that of Bernard Fantus in Chicago by almost 2 years.
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THE HISTORY OF early, mostly catastrophic, attempts at transfusing humans with animal blood and, later, often equally hazardous, human blood has been well reported previously.¹⁻⁵ The medical and surgical clinic founded by the Mayo brothers and their father began as a small group practice about 1900 in Rochester, Minn. This group practice expanded rapidly because of its growing regional and national reputation and probably related to its founding principle articulated in 1910 by Dr William J. Mayo (speaking to the graduating medical class at Rush Medical College) that “the best interest of the patient is the only interest to be considered.” The Mayo brothers were superbly skilled clinicians and surgeons and they gathered around them an ever-expanding coterie of like-minded physicians whose areas of competence and interest stretched far beyond the confines of the operating room. For example, Louis B. Wilson was involved in developing laboratory techniques to enhance the microscopic diagnostic acumen of the pathologists evaluating surgical specimens and he introduced the first standardized use of frozen sections in surgical pathology in the first decade of the 20th century.⁶ Against this background of a growing medical and surgical practice, the prevalence of thyroid goiter disease provided a substrate for the surgical skills of the Mayo brothers and their colleagues. Despite the discovery by Henry Plummer in 1923 at Mayo Clinic of the therapeutic efficacy of Lugol iodine in presurgically reducing thyroid vascularity, goiter surgery remained a potentially bloody procedure, however skilled the surgeons were.

The seminal discovery of what is now universally termed the *ABO system* in 1900 by Landsteiner paved the way for clinical blood transfusions

free of the seemingly capricious occurrence of catastrophic intravascular hemolysis. It is clear from published material that there was strong interest among physicians at Mayo Clinic in blood transfusions as early as 1914. In that year, Bernard Francis McGrath helped modify the original crude aspiration-injection apparatus for performing arm-to-arm blood transfusions. He also developed a method for vascular suturing using human hair as a substitute for the fine silk in common use and designed a cannula forceps through which 2 vessels could be drawn and brought together for suturing.^{7,8} McGrath was an interesting and quite innovative man. He was born on Christmas Day, 1869, in Amesbury, Mass, obtained MD degrees from both Georgetown University and Harvard and had done several years of graduate study in laboratories in Vienna, Austria, and in Dublin, Ireland. He came to Mayo Clinic in 1910 as an “assistant pathologist” (approximately equivalent to a resident today) and quickly became director of experimental surgery and pathology before becoming supervisor of necropsies for more than 4 years. He left Mayo Clinic in June 1915 to become Chair of Experimental Surgery at Marquette University.

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In 1919, John Pemberton⁹ (Fig 1), a surgeon at Mayo Clinic with a worldwide reputation for thyroid surgery, published a remarkable article on blood transfusion with more than 100 references and in which he described techniques of transfusing, donor selection, indications, and adverse reactions. He also described the experience with transfusion at Mayo Clinic up to that date. He indicated that between January 1, 1915, and January 1, 1918, 1036 transfusions were carried out on 429 patients. Of these, 1001 were performed by the “indirect or citrate method,” 30 by a modified cannula-syringe method, and 5 by means of a paraffin-lined cylinder. It is clear from this description that all these transfusions were with “fresh” blood. Apart from those performed arm-to-arm with the cannula syringe, the other transfusions were performed immediately after the blood had been collected in either a paraffin-lined flask or one containing citrate. Both approaches were designed to minimize or prevent clotting before the blood could be administered. The



Fig 1. John DeJ. Pemberton, MD. Thyroid surgeon par excellence who carried out more than 25 000 thyroidectomies during his Mayo Clinic career and described the methods used to transfuse thousands of patients.

outline by Pemberton of the indications for blood in 1919 were as follows:

1. Restoration of the bulk of the circulating fluid,
2. Provision of oxygen and assimilable pabulum for tissues,
3. Increase of the coagulability,
4. Stimulation of the hematopoietic organs, and
5. Increase of resistance to infection by its antitoxic and bactericidal properties.

One can only guess at what “assimilable pabulum” meant! Perhaps it referred to soluble protein content of plasma. He went on to describe the Mayo series of cases transfused between January 1915 and January 1918:

1. Primary (pernicious) anemia, 65 transfusions in 185 cases
2. Secondary anemia, 243 transfusions in 149 cases
 - a. Chronic infection, 24 cases
 - b. Malignancy, 44 cases
 - c. Chronic hemorrhages, 43 cases
 - d. Acute hemorrhages, 7 cases
 - e. Hemolytic jaundice, 4 cases
 - f. Splenic anemia, 10 cases
 - g. Actinomycosis, 2 cases
 - h. Causes unknown, 15 cases
3. Bleeding, 81 transfusions in 59 cases
4. Acute toxic and septic conditions, 34 transfusions in 25 cases
5. Leukemias, 20 transfusions in 10 cases
6. Shock, 1 transfusion in 1 case

Pemberton commented that the sole method of transfusion used at Mayo Clinic between December 1915 and the date of his report in 1919 was the citrate method. His description of blood donor selection included the following statements: “In the selection of a suitable donor, a young healthy, robust individual is desired. Our results tend to corroborate the observation of Peterson that the value of the transfusion is largely dependent upon the individual donor.” Pemberton also indicated that, although “detection of syphilis by examination and by Wasserman testing is within limits,” all donors were so tested. Nevertheless, he commented that all recipients were also advised of the possibility of syphilis transmission. He even described a case of such transmission at Mayo Clinic. Positive syphilis

testing of blood donations did not become national standard practice until the 1940s. He also described the routine use at Mayo of the Brem modification of the Moss agglutination test for patient and donor ABO matching beginning in July 1916. Pemberton also indicated that they made it a point to select recipient and donor of the same ABO type and, where that was not possible, they only used “donors whose cells were not agglutinable by the serum of the patient.” The rationale for this serologic cross-match was explained by Pemberton as being a result of the work of Otterberg and Kaliski who had pioneered this cross-matching approach in 1913. This remarkable report goes on to outline Pemberton’s view of “the three well-recognized accidents associated with and complicating blood transfusions, namely, acute dilation of the heart, embolism from the introduction of air or clotted blood, and hemolysis.” The paper then lists the actual reactions seen in the Mayo series of patients. In 21% of transfusions, a febrile reaction occurred within 15 minutes to an hour with or without malaise, headache, nausea, vomiting, and diarrhea with a small percentage also demonstrating an eruption of herpes within 3 days. Another 15% had a transient elevation of temperature not associated with any other symptoms.

The process of blood donation even by the indirect (citrate) method in the early decades of the 20th century was approached as a surgical procedure and a sterile surgical set of instruments was used each time. Given the time and personal commitment involved for the donor, it is no wonder that donor retention (even with monetary compensation) was a problem (Fig 2).

DONOR'S RECORD 8/25/21

Name Roscoe Donnellson Group No. 2
 Residence 1007 1/2 St. S.W. Tel. No. 5528
 Business Address Mayo Clinic Tel. No. _____
 Wassermann neg Date 12/13/21 O.K. Haines 12/14/21

PATIENT'S NAME	DATE	PATIENT'S NAME	DATE
John Cavill	12/15/21		
		doesn't want to be used any more	

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Fig 2. Blood donor record card from 1921 indicating the desire of this donor to cease donating.



Fig 3. John S. Lundy, MD. Anesthesiologist who set up the Mayo Clinic Blood Bank in 1935.

Interestingly, in the same year as the article of Pemberton, Sanford¹⁰ at Mayo Clinic published a treatise on blood transfusions, indications, donor selection, and techniques. Sanford, who later collaborated with Todd to produce the long-revered textbook of clinical pathology known as *Todd and Sanford*, was already an established laboratory expert and a professor of physiology at Marquette University when he came to Mayo Clinic as a bacteriologist in 1911 and became Head of the Division of Clinical Pathology. His article is remarkable for the detail with which he describes the various techniques for performing what we now call ABO typing and for the clarity of the drawings of the serologic reactions and their interpretation as to blood types. It is clear from this paper that both Moss and Brem methods were in use at Mayo at that time.

The next, and, arguably the most remarkable of all contributors to Mayo’s transfusion pioneers was John Silas Lundy, MD (Fig 3). He was a native of Inkster, ND, who had received his MD degree in 1920 from Rush Medical College. An early personal experience with rather crude anesthetic efforts to subdue him as a 12-year-old for tonsillectomy by his family physician had given him a strong interest in anesthesia. He had

even administered anesthesia for minor operations while he was still in high school. When he began the practice of general medicine in 1920 in Seattle, Wash, because of his interest and experience, he was quickly persuaded to administer anesthesia for his colleagues' cases. In 1924 he was the newly elected secretary of the King County Medical Society and their guest speaker that year was none other than William J. Mayo from Rochester.

Lundy later admitted to using the "modest prerogatives of his new office" to sit opposite Mayo at dinner where they obviously had an interesting conversation because Mayo then and there invited Lundy to come to the Mayo Clinic "to organize a Section devoted to anesthesia."¹¹ For the next 30 years, at Mayo Clinic, all transfusion practice directly involved the anesthesiologists. Lundy developed a strong interest in transfusions and presented a summary report to the medical staff at Mayo Clinic each year which outlined the numbers of transfusions given, reactions, indications for transfusions, and any changes in practices since the last report. These reports were published in the then weekly publication *Proceedings of the Staff Meetings of the Mayo Clinic*.¹²⁻¹⁵

Lundy describes being asked in 1933 to begin having the Section of Anesthesia (which he headed) take formal responsibility for blood transfusion^{16,17} in 1933 at the request of Dr CH Mayo.¹¹ He also described beginning the practice of refrigerating donor blood in 1935 "in the cooler of Dr WC McCarty's lab." Doctor McCarty was one of the preeminent surgical pathologists of the day. Lundy himself goes on to indicate that his implementation of this practice preceded by 1 year the installation of a similar bank at Cook County Hospital in Chicago.¹¹ In 1938 he commented on the increased use of refrigerated blood during 1937.¹⁴ He mentioned the fact that during that year there were fewer reactions with refrigerated blood than with fresh blood.¹⁴ However, it was the 1936 report¹⁷ of Lundy which gave the incontrovertible evidence of having begun the refrigerated banking of donor blood in 1935 for subsequent use. The key paragraph in this report states:

In 1935, we frequently kept citrated blood in the ice box for as long as fourteen days and found that it could be administered satisfactorily with the usual benefits accruing to the

patient and without an undue incidence of untoward reaction. In this way we are able to draw from a donor the blood that we might wish to administer subsequently in divided doses and in small quantities. Thus we escape the necessity of calling the donor each time a transfusion of a small amount of blood is undertaken. This practice also permits the keeping of blood from a universal donor on hand in anticipation of an emergency when immediate transfusion is essential.

Lundy's name is also associated with at least 2 other transfusion-related issues. Kilduffe and DeBakey,¹⁸ in their classic 1942 text *The Blood Bank and the Technique and Therapeutics of Transfusions*, discuss the development of a rotary pump to control the rate of flow and blood being infused. The authors cite the work of Lundy and Rogers¹⁹ at Mayo Clinic in developing this pump. DeBakey had also developed a rotary pump in 1934.

Yet again, Lundy, this time with an anesthesia colleague, R Charles Adams at Mayo Clinic, advocated the use of a hemoglobin "trigger" of 8 to 10 g% for patients considered to be of poor surgical risk.²⁰ This publication seems to have been taken seriously and applied widely, perhaps because of the stature and previous contributions of Lundy. The long-practiced dogma of transfusing surgical patients to get their hemoglobin level to a "safe" 10 g% seems to have begun with this publication.

In the 1930s, operating room tables were modified to be used as blood donor beds at Mayo Clinic. One of these donor "beds" was still being used until the 1990s.

In summary, the early days of transfusion practice at Mayo were replete with examples of innovation and the practical adaptation of devices, some of which were designed for other specific purposes. The evaluation of transfusion results was remarkably well documented as were the characteristics of the donors. Pretransfusion testing was rudimentary and the necessity of obtaining informed consent for transfusions was obviously recognized very early. Finally, Mayo Clinic clearly had established a blood bank of refrigerated donor blood in 1935 to be used for clinical transfusions almost 2 years before the establishment of a similar facility which was opened on March 15, 1937, at Cook County in Chicago by Bernard Fantus.²¹

REFERENCES

1. Gottlieb MA: History of the first blood transfusion but a fable agreed upon: The transfusion of blood to a pope. *Transfus Med Rev* 5:228-235, 1991
2. Myle BA: The first recorded blood transfusions: 1656 to 1668. *Transfusion* 30:358-362, 1990
3. Hess JR, Schmidt PJ: The first blood banker: Oswald Hope Robertson. *Transfusion* 40:110-113, 2000
4. Giangrande PLF: The history of blood transfusions. *Br J Haematol* 110:758-767, 2000
5. Huestis DW: The first blood transfusions in Russia (1832). *Transfusion* 44:1367-1369, 2004
6. Wilson LB: A method for the rapid preparation of fresh tissue for the microscope. *JAMA* 45:1737, 1905
7. McGrath BF: A simple instrument for transfusion. *JAMA* 62:40, 1914
8. McGrath BF: A simple apparatus for transfusion by the aspiration-injection method. *Surg Gynecol Obstet* 18:376-377, 1914
9. Pemberton JDeJ: Blood transfusion. *Surg Gynecol Obstet* 28:262-276, 1919
10. Sanford AH: Blood transfusion: Indications for its use; methods of selecting donors; and a brief consideration of technique. *Med Clin North Am* 3:801-819, 1919
11. Lundy JS: From this point in time: Some memories of my part in the history of anesthesia. *J Am Assoc Nurse Anesth* 34:95-102, 1966
12. Lundy JS, Tovell RM: Annual report for 1932 of the section of anesthesia: Including data of blood transfusion. *Proc Staff Meet Mayo Clin* 8:646-648, 1933
13. Lundy JS, Tovell RM: Annual report for 1934 of the section of anesthesia: Including data of blood transfusion. *Proc Staff Meet Mayo Clin* 10:257-272, 1935
14. Lundy JS, Tuohy EB, Adams RC: Annual report for 1937 of the section of anesthesia: Including data of blood transfusion. *Proc Staff Meet Mayo Clin* 13:177-188, 1938
15. Lundy JS, Tuohy EB, Adams RC, et al: Annual report for 1939 of the section of anesthesia: Including data of blood transfusion. *Proc Staff Meet Mayo Clin* 15:241-256, 1940
16. Lundy JS: Blood transfusions. *Surg Clin North Am* 14:721-727, 1934
17. Lundy JS, Tovell RM, Tuohy EB: Annual report for 1935 of the section of anesthesia: Including data of blood transfusion. *Proc Staff Meet Mayo Clin* 11:421-432, 1936
18. Kilduffe RA, DeBakey M: The blood bank and the technique of therapeutics of transfusions. St Louis, MO, The C.V. Mosby Co, 1942, pp 392
19. Lundy JS, Rogers DA: Hand roller for rapid intravenous administration of urgently needed blood or solutions. *Proc Staff Meet Mayo Clin* 13:726-727, 1938
20. Adams RC, Lundy JS: Anesthesia in cases of poor surgical risk. Some suggestions for decreasing the risk. *Surg Gynecol Obstet* 64:1011-1019, 1942
21. Fantus B: The therapy of the Cook County Hospital. *JAMA* 109-131, 1937