

# Neurological illnesses of Franklin Delano Roosevelt: from middle-age acute ascending paralysis to final cerebrovascular stroke

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## ABSTRACT

**Introduction.** Franklin Delano Roosevelt (FDR) (1882-1945) was elected President of the United States for four consecutive terms from 1933 to 1945. At age 39 he presented acute ascending paralysis. The President died at age 63 due to cerebral hemorrhage.

**Objective.** This study presents a historical review of FDR's neurological illnesses.

**Development.** The article is organized into three sections. The first is devoted to a brief biographical analysis of Roosevelt. The second revises in detail the characteristics of his acute ascending paralysis, which was categorized as paralytic polio. Given the early and severe sensory semiology, an alternative diagnosis of Guillain-Barré syndrome is proposed. An important sequela was permanent flaccid paraplegia, which FDR overcame by means of long-term rehabilitation therapy. He created the Warm Springs Foundation, which contributed to developing rehabilitation programs and research projects on poliomyelitis. The third section addresses Roosevelt's treatment for hypertensive cardiac disease, and subsequent death due to a sudden cerebral hemorrhage.

**Conclusion.** FDR is an emblematic example of how to overcome the hardships of illness, particularly through the extremely difficult circumstances he had to endure.

## KEYWORDS

Acute ascending paralysis, cerebral hemorrhage, cerebrovascular stroke, Franklin Delano Roosevelt, FDR Library & Museum, Guillain-Barré syndrome, hypertensive cardiac disease, poliomyelitis, Roosevelt's Little White House State Historic Site, Warm Springs Foundation

## Introduction

The prevalence of diseases of the nervous system among famous people is similar to that in the general population, and is estimated to be around 10% of all diseases.<sup>1</sup> With regard to the type of disease, acute cerebrovascular diseases prevail, followed by tumors and neurodegenerative disorders.

In the Preface to his biography of Franklin Delano Roosevelt (FDR), Brinkley<sup>2</sup> wrote that:

FDR may be the most chronicled man of the twentieth century. He led the United States through the worst economic crisis in life of the nation and through the greatest and most terrible war in human history. His extraordinary legacy, compiled during dark and dangerous years, remains alive in our own, troubled new century as an inspiring and creative model to many, and a symbol of excessive government power to many others.

The aim of this paper is to analyze two neurological disorders suffered by president FDR: *i)* acute ascending



**Figure 1.** Franklin Delano Roosevelt's home in Hyde Park, New York, is officially named Springwood, but the Roosevelts always referred to the site simply as *Hyde Park* or *The Big House*; it sits on a 33.23 acre estate. Soon after his death, the family transferred ownership to the National Park Service. The Home of Franklin D. Roosevelt National Historic Site, opened to the public in 1946, has remained in continuous operation as a museum ever since. Although the house belonged to his mother until her death in 1941, Springwood was FDR's primary residence throughout his life. FDR was buried in the rose garden adjacent to the house after his death on April 12, 1945; Eleanor Roosevelt was also buried there, beside FDR, following her death in 1962. Image taken from Roosevelt Library in Hyde Park,<sup>12</sup> where it is stated that this picture is in the public domain and can be used without further permission.

palsy occurring in August 1921, at age 39, followed by leg weakness, surprisingly unbeknownst to most of his contemporaries; and *ii*) cerebrovascular stroke leading to his death in April 1945.

### Material and methods

For his great reputation and historic responsibility and capability to act in very difficult times, FDR is indeed one of the most chronicled people, with a Google search returning 55 900 000 results and 277 000 videos (as of February 29, 2024). This paper draws data from five biographies of FDR<sup>2-6</sup> and five online documentary films.<sup>7-11</sup> Online free information (documents, photographs, and videos) from the FDR Presidential Library and Museum<sup>12</sup> and Roosevelt's Little White House State

Historic Site was also used.<sup>13</sup> A systematic computer-based literature search was conducted in PubMed database, using three Medical Subject Headings (MeSH) terms in the title: *i*) Franklin D. Roosevelt and poliomyelitis; *ii*) Franklin D. Roosevelt and Guillain-Barré syndrome; and *iii*) Franklin D. Roosevelt and acute stroke. Papers or documentaries published in English or Spanish were selected. A manual search of relevant review papers was also performed.

### Results

This section is divided into three parts: the first is devoted to a brief biography of president FDR; the second concerns his acute ascending paralysis; and the third addresses the final and fatal cerebrovascular disorder.

### 1. *Biography of Franklin Delano Roosevelt*

This brief summary was extracted from five biographies<sup>2-6</sup> and selected online documentaries and archives.<sup>7-13</sup> FDR was born on January 30, 1882, on his family's estate in Dutchess County, New York, and died on April 12, 1945, in Warm Springs, Georgia. He was the only child of parents who belonged to the local aristocracy of New York. His parents lived their lives and raised their child in a manner reminiscent of the English aristocracy. Until he was 14 years old, he lived in a world dominated by adults: his Swiss tutors, who supervised his lessons at home or during the family's annual travels through Europe, and particularly his mother, Sara Delano, who devoted virtually all of her energies to raising her only child. He practiced several sports including golf, tennis, polo, and sailing (it is said that FDR was a good rider, a golf enthusiast, and a passionate sailor). In the fall of 1896, Franklin left his parents for first time to attend Groton, a rigorous boarding school in a small Massachusetts town. There, he paid little attention to athletics, which dominated school life, but did reasonably well academically, though at the end of his four-year stay he was denied the principal honors of the school, and was disliked by many classmates for what they considered a cocky demeanor and an irritating gregariousness.

As recounted by Brinkley,<sup>2</sup> "entering Harvard College in 1900, he set out to make up for what he considered his social failures at Groton. He worked hard at making friends, ran for class office, and became president of the student newspaper, the *Crimson*"; the latter role was more a social distinction at the time than a journalistic one. In 1903, FDR graduated from Harvard in Humanities and History. Between 1904 and 1907, he studied at Columbia Law School, where he did not complete the requirements for a degree, but he passed his bar exams and spent several years "desultorily practicing law" in New York City.<sup>2</sup> In 1905 he married his distant cousin Eleanor Roosevelt, niece of President Theodore Roosevelt. Between 1906 and 1916 they had six children (Anna, James, and Elliot born in 1906, 1907 and 1910, respectively; a first Franklin was born and died in 1909; and the second Franklin and John were born in 1914 and 1916).

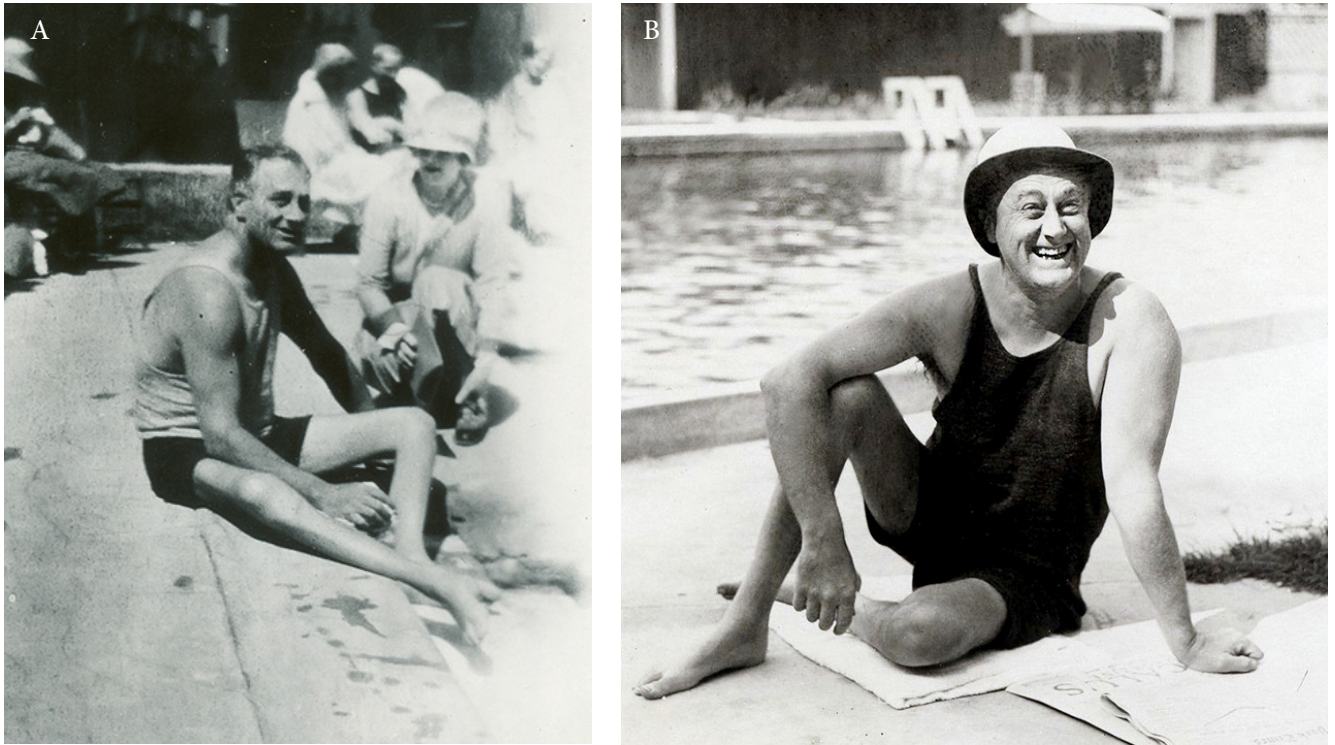
FDR's political career began in 1910, when he accepted an invitation from Democratic Party leaders in Dutchess County to run for the state senate; he narrowly won the election. In 1912 he was easily re-elected, in part because he had by then enlisted the aid of a politically

knowledgeable journalist, Louis M. Howe, who remained his trusted advisor until his death in 1936. Early in 1913, President Woodrow Wilson offered FDR an appointment as Assistant Secretary of the Navy, where he remained throughout the Wilson administration (1913-1920). This was followed for a long period of relative political inactivity as a result of his acute ascending paralysis (see below). He was governor of New York State (1928-1932), and subsequently President of the United States over four consecutive terms (1933-1945), with the fourth not being completed due to his untimely death. It is beyond the scope of this paper to analyze the immense contributions during his unique prolonged Presidency, which we may summarize in four basic points: *i*) the successful New Deal, a plan to lift Americans out of the Great Depression as quickly as possible; *ii*) his role as one of the architects of the Allied victory in the Second World War; *iii*) promotion of the Manhattan Project, which culminated in the development of the first atomic bomb; and *iv*) the role of FDR as one of the main founders of the United Nations, a term coined to describe the Allied countries during the Second World War.

### 2. *Acute ascending palsy: from Campobello Island to New York City Presbyterian Hospital*

It seems important to begin this section with the precedent stressful situations confronted by FDR in the spring and summer of 1921, which Dallek<sup>5</sup> describes as follows:

Settling into his new work routine and blunting an ongoing Senate subcommittee attack on his part in the Navy's response to the Newport scandal commanded his attention. In the middle of July, he returned to Washington to refute committee accusations that he had organized and directed the entrapment of homosexual sailors by "disgraceful" actions. Although the allegations ended up as one-day newspaper stories having little resonance, the anxiety of having to deal with such unpleasantness drained his energies. At the end of July, he welcomed the opportunity to escape a steamy Manhattan for a Boy Scout outing in upstate New York at Bear Mountain, where he acted as a toastmaster. When he arrived at Hyde Park on July 29, his secretary Marguerite (Missy) LeHand thought he seemed exhausted, worn down by the tensions over the Newport case, the summer heat, and the demands of performing at the Boy Scout conclave. He was more than ready to escape to Campobello on August 5 by sailing to Maine with friends on a 140-foot power



**Figure 2.** Photographs showing Franklin D. Roosevelt in a bathing suit seated at the edge of a pool at Warm Springs in 1924 (A) and 1925 (B). The images show marked muscle atrophy of the lower legs and thighs. Muscle contour of upper limbs is preserved; note, however, the apparent increase of muscular mass in the right photo, undoubtedly due to his rehabilitation efforts, including prolonged swimming pool exercises (see video in Supplementary material 3). Images taken from Roosevelt Library in Hyde Park,<sup>12</sup> where it is stated that these pictures are in the public domain and can be used without further permission.

yacht docked in New York harbor. As the most experienced sailor abroad, Franklin took the helm to steer the yacht through treacherous crosscurrents along the Maine coast – an exhilarating but exhausting task that brought the crew safely into harbor on August 8. [...] When he woke early in the morning of August 9, he faced another day on nonstop activity[...]. Deep-sea fishing with his friends on the power yacht occupied the hours from dawn to late afternoon, and during the outing, he slipped overboard while moving back and forth on the slippery deck and had to be helped back onto the boat. The water was “so cold,” he said, “it seemed paralyzing.” It was an apt metaphor, for apparently at some point in the previous two weeks, the incubation period for poliovirus, he had contracted

the potentially crippling disease[...]. On August 10, despite feeling “oddly depleted,” he began another day of nonstop physical activity: sailing with Eleanor [his wife] and the older children on his 25-foot yacht; joining volunteers to beat back a fire on a nearby island; and trotting a mile and a half from the Roosevelts’ home across the three-mile-wide Campobello to a swimming hole, followed by another run to a beach for a dip in the ocean, and a final run back to the house. Feeling totally spent, achy and chilled, Franklin skipped dinner and went to bed.

To clarify the issue, it is convenient to add that Campobello Island is a civil parish in southwestern New Brunswick, Canada, near the border with Maine,

United States, where the Roosevelt family had a 34-room cottage.

It is worth noting that FDR's medical records are not available; consequently, the following clinical description is taken, almost literally, from the peer-review papers by Ditunno and Herbison<sup>14</sup>, Goldman et al.,<sup>15</sup> and Friedenber.<sup>16</sup> Furthermore, internal correspondence around FDR's acute paralytic disorder in 1921, comprising 91 letters or telegrams, is available digitally at the Franklin D. Presidential Library and Museum<sup>12</sup>; these are compiled in the Appendix of the book by Goldman and Goldman.<sup>6</sup> Furthermore, very useful information is available in digital archives from Roosevelt's Little White House Historic Site.<sup>13</sup> For their historical interest (see below), two letters (one from Eleanor Roosevelt to her son James, August 14, 1921, and one from FDR to Dr William Egleston, October 7, 1924) are included as Supplementary Material 1 and 2.

The next morning (August 11), FDR's left leg was weak and by afternoon it was paralyzed. That evening the other leg began to weaken. On August 12, he could not stand because of bilateral paralysis. He felt "thoroughly achy all over."<sup>15</sup> He had severe back pain, headache, and leg pain with temperature increase to 102°F (38.9°C) (see Supplementary material 1 and 2). FDR was unable to sit unaided. His legs were numb. Moreover, "his skin and muscles had developed a sensitivity to touch so painful that he could not stand the pressure of the bedclothes, and even the movement of the slightest breeze across the skin caused acute distress."<sup>15</sup> FDR wrote that "all the muscles from the hips down were extremely sensitive to the touch and I had to have the knees supported by pillows. This condition of extreme discomfort lasted about three weeks" (Supplementary material 2). The family physician, Dr Eben H. Bennet from Lubec (a small town in Washington County, at the entrance of Passamaquoddy Bay), examined him and declared he had a "heavy cold."<sup>15</sup> Furthermore, it has been argued that "the paralysis was most likely caused by strenuous activities in the pre-paralytic phase of his illness"<sup>14</sup> (see above).

Goldman et al.<sup>15</sup> recount how "by 13 August, he was paralyzed from the chest down. His arms, shoulders and thumbs were weak." Dr William W. Keen, a famous retired neurosurgeon from Philadelphia who was on holiday nearby in Bar Harbor, Maine, examined FDR that day, diagnosing him with "a clot of blood from a sudden congestion – settled in the lower spinal cord."<sup>15</sup> "During

the next few days, FDR's hands, arms and shoulders became very weak. Because he had difficulty in defecation he required frequent enemas. He could not pass urine for two weeks beginning on about 12 August."<sup>15</sup> As a result, repeated bladder catheterizations, carried out by Eleanor, were necessary. The fever continued for a week. "On August 18 he was delirious briefly. His mental state otherwise remained normal."<sup>15</sup>

Fearing that Franklin had poliomyelitis, his wife kept their children away from him. Roosevelt's uncle, Franklin A. Delano, consulted Dr Samuel A. Levine, an internist at Peter Bent Brigham Hospital (Boston, Massachusetts), who said "that it was unquestionably Infantile Paralysis,"<sup>15</sup> thus providing even more reason to believe that FDR had been struck by paralytic polio.

On the fifteenth day of the illness, FDR was examined by Dr Robert W. Lovett, an orthopedist from the Infantile Paralysis Commission at Harvard. The patient had a temperature of 100°F (37.7°C). "He was paralyzed from the waist down, his back muscles were very weak and there was involvement of the face and left thenar eminence. He continued to experience pain in the legs to the slightest touch and could not urinate. Lovett's diagnosis was poliomyelitis."<sup>15</sup>

Goldman et al.<sup>15</sup> continue:

The paralysis progressed and severe pains continued. In mid-September FDR was admitted to New York City Presbyterian Hospital. His physician, George Draper, wrote to Lovett on 24 September 1921 (cf., Goldman and Goldman<sup>6</sup>): "I am much concerned at the very slow recovery both as regards the disappearance of pain [...] and as to the recovery of even light power to twitch the muscles. There is marked falling away of the muscle masses on either side of the spine in the lower lumbar region [...]. There is marked weakness of the right triceps, and unusual amount of gross muscular twitching in the muscles of both forearms. He coordinates on the fine motion of his hands very well now so that he can sign his name and write a little better than before. [...] The lower extremities present a most depressing picture. There is little action in long extensors of the toes of each foot; a little in the peronei; a little ability to twitch the bellies of the gastrocnemii, but not really extend the feet. There is little similar power in the left vastus, and on both sides similar voluntary twitches of the hamstrings can be accomplished."



**Figure 3.** Roosevelt's Little White House. This is one of Georgia's most popular historic sites, drawing more than 100 000 visitors each year. Image taken from Roosevelt's Little White House Historic Site,<sup>13</sup> where it is stated that the picture is in the public domain and can be used without further permission.

Facial paralysis disappeared, but he continued to present dysesthesia in the lower extremities. Other neurological findings, including deep tendon reflexes, sensory exploration, and such laboratory studies as lumbar cerebrospinal fluid analysis were not mentioned. Goldman et al.<sup>15</sup> recount how “during the next six weeks, the symmetric weakness of his upper extremities and trunk subsided gradually. He was able to sit, urinate and defecate. After discharge on 28 October 1921, the lower abdominal and lower back muscles began to strengthen. The dysesthesia abated over a period of six months, but lower extremities did not improve.”

#### 2.1. Acute ascending palsy: rehabilitation program at Roosevelt's home

After having been discharged from hospital, FDR moved back to his home (The Roosevelt Springwood Estate)

(Figure 1).<sup>12</sup> Here, as noted by Friedenberg,<sup>16</sup> “Roosevelt rose to the challenge. He firmly believed that, with perseverance, effort, and knowledge of the disease, he was strong enough to overcome such physical disability. He set himself a goal to walk without braces or crutches.” In January 1922, FDR's lower legs “suddenly hyper-flexed and locked.”<sup>15</sup> Goldman et al.<sup>15</sup> describe how, because of this, “his legs were placed in casts for three weeks and were extended gradually by ‘insertion of wedges behind the knees.’ After the casts were removed, he was fitted with leg braces, a lower abdominal sling and crutches. He was able to stand but only with those aids.” According to Friedenberg<sup>16</sup>:

In the years after 1922, he devoted much of his time to communicating with orthopedists and became familiar with the exercises [including swimming] and treatment recommended by them. In letters

to doctors and friends, he remained a confirmed optimist, describing how he could move a toe better today than yesterday. At his family home at Hyde Park, he was determined to walk the length of his driveway, which was a quarter of a mile. Each day, wearing his braces and supported by crutches, he lurched along until exhausted, but never could accomplish this goal. He became an expert on the rehabilitative treatment of the disease, advising others how to exercise [see Supplementary material 2].

During the winters, he lived on a houseboat in Florida, hoping that the sun and fresh air would help revive his legs.

FDR returned to public life at the 1924 Democratic National Convention, which took place in New York (from June 24 to July 9), an event fantastically reported in a Timeline documentary.<sup>8</sup> FDR was booked to give the nominating address on behalf of the candidate Alfred E. Smith. This event would be his first appearance in public since he had been struck by polio in 1921. He had practiced for hours with his teenage son James, so as to be ready to take those vital steps. Behind the scenes, Roosevelt was helped to his feet and his leg braces were locked in place, then James gave him his crutches: he slowly heaved himself across the stage, eyes down and face fixed in concentration. When he reached the rostrum, FDR handed back his crutches; he held onto the podium grinning broadly, as the crowd cheered. He spoke for a full half hour, with energy and animation seeming almost to glow in the spotlight. At the end he praised Smith as the happy warrior of the political battlefield, a reference to Wordsworth's poem honoring Admiral Lord Nelson. Nevertheless, it was clear from the press reaction that the happy warrior who stood out on that hot June day in New York was not Alfred E. Smith but rather Franklin D. Roosevelt.

## 2.2. Acute ascending palsy: the rehabilitation program continues at Warm Springs

Warm Springs (Georgia, US) is home to mineral springs that flow nearly constantly at a temperature of 88°F (31°C); the water has high mineral content, increasing its net buoyancy. Beginning in the early 19th century, Georgians had begun spending time in Warm Springs in a belief that the warm thermal waters would aid in recovering from illnesses. It was one of the best-known thermal springs in the United States by 1920.<sup>10,13</sup>

According to Fridenberg,<sup>16</sup> “a business associate, George Foster Peabody, co-owner of Georgia Warm Springs, wrote to Roosevelt about Lewis Joseph, a patient with poliomyelitis who had spent time in the pool at Warm Springs and had recovered sufficiently to walk.” In October 1924,

Roosevelt traveled to Warm Springs to see Joseph and discuss his routine exercises and swimming. Roosevelt was impressed and even more convinced after using the pool [...]. His days were spent exercising in the water, then exercising out of the water, followed by periods of sun bathing. After such a regimen, he tested his muscles and was sure they had gained strength [Figure 2<sup>12</sup>; video: Supplementary material 3]. [...] Ultimately, he used part of his personal wealth to purchase the spa as nonprofit organization; his primary motive was to allow those less fortunate to recover function after paralysis.<sup>16</sup>

It became the Warm Springs Foundation, where hundreds of patients with polio came for treatments. And Roosevelt would stay at the Little White House, which was built in 1932 (Figure 3).<sup>12</sup>

In April 1926, at the Annual Meeting of the American Orthopaedic Association (AOA), in Atlanta, Roosevelt had requested permission from the president of the Association, Dr Michael Hoke, to be included in the program and to address the membership.<sup>16</sup> When Hoke refused, FDR then requested that the Association form a committee to investigate the Warm Springs Foundation and its rehabilitation successes. Several members of the AOA committee supported FDR's proposal, creating the Freiberg Committee, whose actions are thoroughly reviewed by Friedenber,<sup>16</sup> who summarizes them as follows:

It is fair to conclude that Franklin D. Roosevelt, as a result of poliomyelitis, was well known to the orthopedic community, was familiar with their viewpoints, and felt comfortable talking their language. Moreover, he had close friends and was in communication with leading orthopedic surgeons of the country. The national publicity surrounding Roosevelt and his every undertaking was reflected on orthopedic surgeons throughout the country.

Afterwards, the Warm Springs Foundation gave support to the development of poliovirus vaccines.<sup>6</sup> Since the development of the polio vaccine in 1955, Warm Springs has shifted its focus from polio to other disabilities.<sup>13</sup>

This Warm Springs period is well documented in the 2005 film *Warm Springs*.<sup>A</sup>

### 2.3. Acute ascending palsy: coping with the aftermath

As reported by Brinkley,<sup>2</sup>

Roosevelt's long search for a cure for polio inevitably ended in failure. Eventually, he became at least partially reconciled to his paralysis, and he learned to disguise it for public purposes by wearing heavy leg braces; supporting himself, first with crutches, and later with a cane and the arm of a companion; and using his hips to swing his inert legs forward. He tried to compensate for the discomfort his disability might create in those around him with an aggressively cheerful countenance. As he labored to move from room to room, and while aides lifted him in and out of cars and trains, he smiled broadly, wave cheerfully, chattered, and told jokes – anything to distract others from his physical limitations. Most of his public appearances were carefully staged to hide his laborious movements. He was often seen standing, but only rarely “walking.” When he traveled by train, he always spoke from a rear platform while supported by a reinforced podium [Figure 4<sup>12</sup>]. When he moved about by automobile, he spoke to crowds from the back seat of an open car or used specially constructed ramps to have himself driven as close to podium as possible [see Figure 4<sup>12</sup>]. He painted his steel braces black and had his trousers cut long to obscure them from the public. Later, when he was president, White House aides ensured that no one ever photographed him in a way that would reveal his disability. Of all the thousands of photographs of him in the Roosevelt Library in Hyde Park, only a handful [either family snapshots or military awards] showed him sitting in a wheelchair [Figure 5<sup>12</sup>]. [...] So effective was this deception (and so cooperative was the press in preserving it) that few Americans knew that Roosevelt could not walk.

### 2.4. Acute ascending palsy: an immutable diagnosis of paralytic polio?

In both the medical and the general literature, FDR's diagnosis of paralytic polio was accepted without reservation. An alternative diagnosis has recently been offered; this question will be addressed in the Discussion.

<sup>A</sup>*Warm Springs* [film]. Directed by: Sargent J. United States: HBO Films; 2005. <https://www.filmaffinity.com/us/film778671.html>

### 3. Franklin D. Roosevelt's final illness

Biographies, documentaries and specialized articles coincide that soon after the Tehran Conference (from November 28 to December 1, 1943), on Christmas Day 1943, FDR complained of feeling unwell.<sup>2-5,7,9,11-13,17,18</sup> The sequence of events was reported as follows: “He exhibited a persistent cough and fatigue. During the early months of 1944 the President had good days and bad days. But as February led into March, the President's declining health could no longer be ignored,”<sup>18</sup> particularly by his secretary Grace Tully and his daughter Anna:

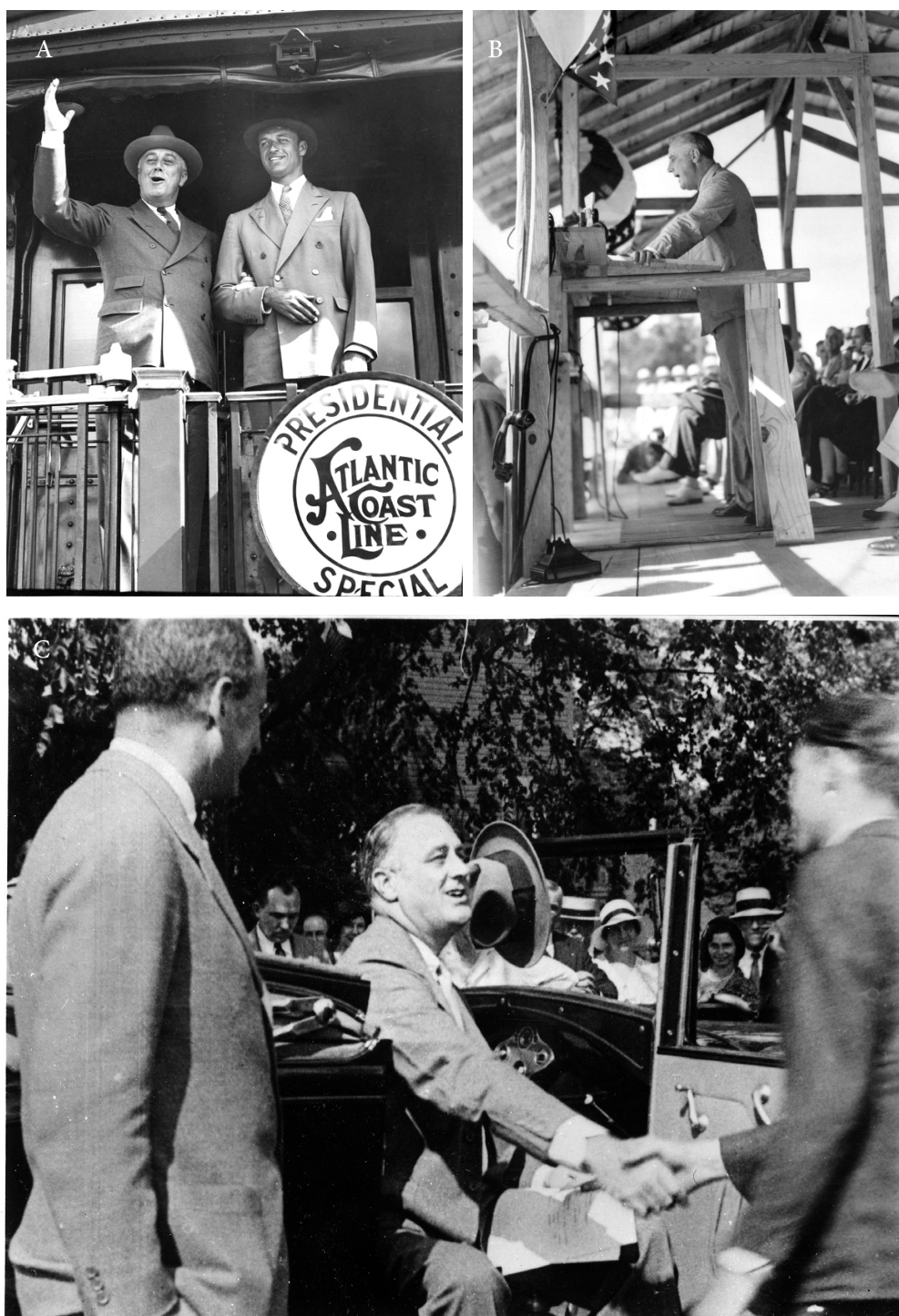
The last week of March, the President's temperature reached 104°F [40°C] and he took to his bed. Anna confronted Admiral Ross McIntire, the President's White House physician. McIntire responded that FDR was simply having a bout of seasonal flu. Anna was not persuaded and pushed for more to be done. [...] McIntire made arrangements for FDR to have a full checkup at the Bethesda Naval Hospital. On March 27, 1944, as the President was getting into the car, White House aide William Hassett asked FDR how he felt. FDR said, “I feel like hell!” On arrival at the hospital FDR was met by Lt. Commander Dr Howard Bruenn of the Naval reserve, a cardiologist from Columbia-Presbyterian Hospital in New York. Bruenn was *shocked by the President's appearance*.<sup>18</sup>

Before proceeding, it is important to underline that from now until FDR's death, Bruenn was the President's attending physician, accompanying him at all times. He gave a detailed and excellent description of FDR's clinical progression between March 27, 1944 and April 12, 1945, when at 15:35, after his last medical examination, he said in moving terms, “I pronounced him dead.”<sup>19</sup>

Several passages of the paper by Bruenn<sup>19</sup> are reproduced below:

Physical examination on March 27, 1944, showed a temperature of 99°F [37.2°C] by mouth, pulse 72/min, and respiration of 24/min. He appeared to be very tired, and his face was very gray. Movement caused considerable breathlessness. [...] He coughed frequently during examination but produced no sputum. He was comfortable in a low position on a Gatch bed but appeared to be slightly cyanotic. The ocular fundi showed occasional arteriovenous nicking but no hemorrhage or exudate. [...]





**Figure 4.** Three photographs showing Franklin D. Roosevelt in public appearances. A) FDR supported by and holding the arm of his son James, waving to a crowd from the back of a train in 1934. B) FDR dedicates the Lamar Electric Membership Corporation Rural Electrification Administration Project in Barnesville, Georgia, on January 23, 1943; note that he stands against the rostrum with both hands, leaning the body forwards. C) From the back seat of his car, FDR congratulates a boy raising pheasants for one dollar each, with Henry Morgenthau Jr. (dated 1932). Images taken from Roosevelt Library in Hyde Park,<sup>12</sup> where it is stated that these pictures are in the public domain and can be used without further permission.

Breath sounds were heard throughout and were accompanied by numerous sibilant and sonorous rales. The lung bases appeared to be clear. [...] The heart rhythm was regular. There was a blowing systolic murmur at the apex. The second aortic sound was loud and booming. [...] Blood pressure 186/108 mm Hg. [...] The radial pulses were full. [...] The liver was not palpable, and there was no peripheral edema. [...] An electrocardiogram showed sinus rhythm with deep inversion of the T waves in leads I and CF4 (only one precordial electrode position was used). [...] Fluoroscopy and X rays of the chest showed a considerable increase in the size of cardiac shadow. [...] The enlargement of the heart was mainly of left ventricle. The great-vessel shadow was also increased in size. This enlargement was apparently due to a diffusely dilated and tortuous aorta, including the ascending, arch, and thoracic portions.

Bruenn made a diagnosis of hypertension, hypertensive heart disease, cardiac failure (left ventricular), and acute bronchitis. Therapeutic recommendations included bed rest for one to two weeks with nursing care, digitalization, a light diet with restricted salt intake, codeine for control of cough, and sedation to ensure rest and a refreshing night's sleep.<sup>19</sup> This memorandum was initially rejected, and Bruenn had to battle with his superior, Admiral McIntire, about the course of treatment. After a consultation with two well-known doctors, James Paullin of Atlanta (President of the American Medical Association) and Frank Lahey of Boston (founder of the famous Lahey Clinic in Boston) and not without disagreements, the good clinical sense of Dr Bruenn prevailed. Limitation of daily activity, and curtailing of cigarettes (maximum 10/day) and cocktails were added to the treatment recommendations.

As recounted by Autenrieth<sup>18</sup>:

The American public would get their first hint of FDR's failing health during a radio broadcast that the President gave from the deck of a destroyer in the Bremerton, Washington Shipyard [Figure 6]. The President decided to stand up for his speech. He had not worn his leg braces for several months, and he had lost almost 20 pounds [9 kg]. His leg braces no longer fit properly and painfully dug into his flanks. There was a stiff breeze which caused the ship to rock, making it very difficult for FDR to hold on the podium and his notes at the time.

It came off in a halting, rambling way as he talked about his recent travels to military bases around the Pacific. Sam Rosenman (one of FDR's speech writers) even said, "it looks like the old master has lost his touch." At about ten minutes into his talk, FDR began to have severe chest pain radiating into both shoulders. He somehow got through the speech. Immediately afterwards he confessed this episode to Dr Bruenn who had been waiting below decks. The doctor gave the President an electrocardiogram immediately, and to his relief saw that it was a transient event and caused no permanent damage to FDR's heart.

Dr Bruenn carried out serial clinical evaluations. However, at no time did the President ever comment on the frequency of the visits or question the reason for the electrocardiograms and the other laboratory tests that were performed from time to time; nor did he ever have any questions as to the type and variety of medications that were used.<sup>19</sup>

Just after the election for his fourth term, with the inaugural address given on January 20, 1945, the President's health resumed its decline.<sup>18,19</sup> His appetite faded and he lost more weight. His blood pressure was reaching high levels, climbing to 260/150 mm Hg. In spite of this, on January 23 FDR left for the Yalta Conference (February 4 to 12). For the first time, Dr Bruenn detected regressive pulsus alternans. Photos taken at the conference show the President looking 20 years older than he was (Figure 7).<sup>12</sup>

By the end of March he began to look far worse. A period of total rest was urged. Accordingly, on March 29, the President left Washington for Warm Springs. After a transient improvement, on April 12 he suddenly complained of a terrific occipital headache, and lost consciousness a minute or two later. When Dr Bruenn saw him, 15 minutes later, he was pale, cold, and sweating profusely. He was totally unconscious with fairly frequent generalized tetanic contractions of mild degree. The pupils of the eyes were initially of equal size, but a after a few minutes the right pupil became widely dilated. FDR died two hours later.<sup>19</sup>

## Discussion

FDR's neurological disorders will be analyzed separately, in the order in which they appear in the preceding sections.



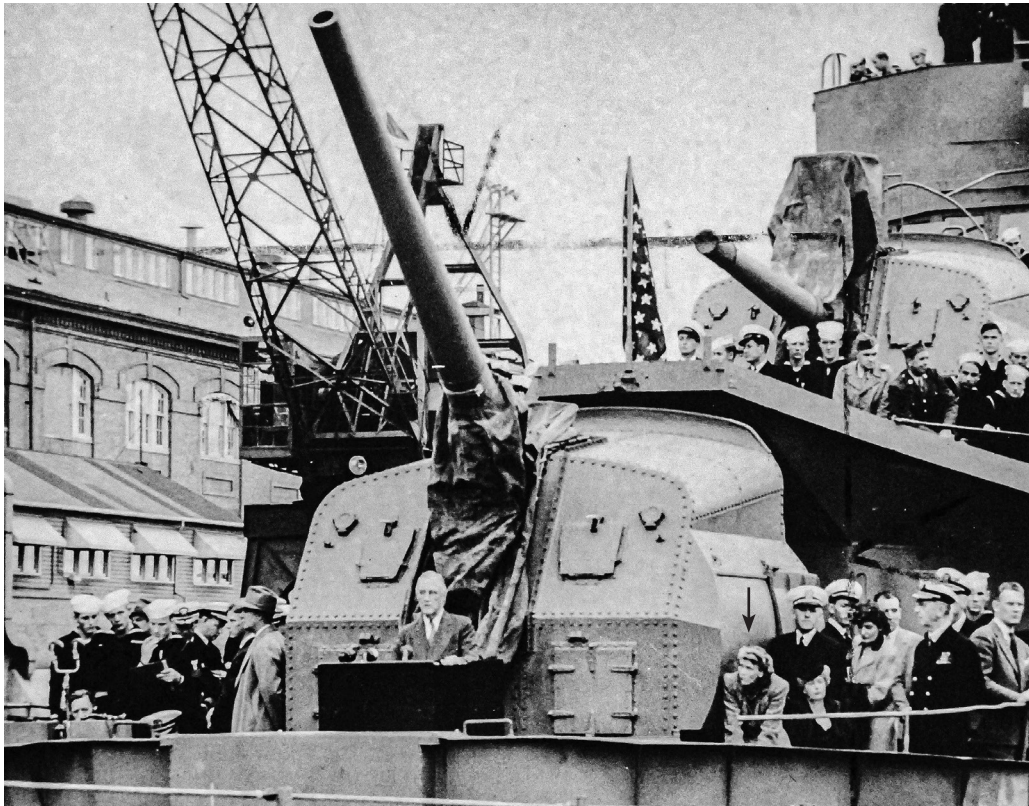
**Figure 5.** Two photographs showing Franklin D. Roosevelt seated in daily life. A) FDR in his wheelchair on the porch at Top Cottage in Hyde Park, New York, with Ruthie Bie and Fala (his Scottish terrier). This photograph was taken by his friend Margaret “Daisy” Suckley in February 1941. B) FDR bestows the Congressional Medal of Honor on Brigadier General William H. Wilbur with General George C. Marshall and General George S. Patton in Casablanca, Morocco, on January 22, 1943. Images taken from Roosevelt Library in Hyde Park,<sup>12</sup> where it is stated that these pictures are in the public domain and can be used without further permission.

### 1. Acute ascending paralysis: paralytic polio or Guillain-Barré syndrome?

In 1921, at age 39, when the President developed his acute ascending paralysis, Guillain-Barré syndrome (GBS) had only recently been described in the French literature<sup>20</sup> and was practically unknown outside of France. In fact, 20 years after the original description of GBS, Georges Guillain<sup>21</sup> himself wrote a review article in the *Archives of Neurology and Psychiatry*, explaining in the American literature the diagnostic criteria for “his disease.” In the same way, two syndromes that had been reported by the time and now entering under the umbrella of GBS, acute ascending paralysis of Landry and acute febrile polyneuritis of Osler,<sup>22</sup> were not taken into account. Leaving

aside some initial diagnostic doubts aside, a firm diagnosis of paralytic polio was established, with complete and permanent flaccid paraplegia as a sequela, forcing FDR to use a wheelchair.<sup>2-6,7-16</sup> He fought unremittingly against paralysis by using heavy leg braces and learning and practicing rehabilitation programs, which allowed him first to support himself with crutches, and subsequently to walk short distances leaning on a cane or on a companion. FDR was able to conceal his gait difficulties to such a degree that few Americans knew that he could not walk unaided. FDR promoted the Warm Springs Foundation to favor non-wealthy polio patients.<sup>13</sup>

In 2003, Goldman and colleagues<sup>15</sup> analyzed the likelihoods (posterior future probabilities) of paralytic



**Figure 6.** FDR speaks at Bremerton Navy Yard on August 12, 1944, as Anna Roosevelt (arrow) looks on, concerned. This picture, from the Library of Congress, is in the public domain.

polio and GBS, investigating Roosevelt's semiology by Bayesian analysis. Posterior probabilities were calculated by multiplying the prior probabilities (disease incidence in Roosevelt's age group) by the symptom probability (likelihood of a given symptom occurring in a disease). The symptoms studied from FDR's case were as follows: *i*) ascending, nearly symmetric flaccid paralysis that progressed for some 10-13 days; *ii*) facial paralysis; *iii*) prolonged bladder and bowel dysfunction; *iv*) numbness and dysesthesia; *v*) absence of meningismus; *vi*) fever; *vii*) descending pattern of recovery from paralysis; and *viii*) permanent paralysis. The authors concluded that six of these eight posterior probabilities strongly favored GBS. This conclusion was dismissed by Ditunno and colleagues,<sup>23</sup> who argued that the most significant diagnostic features of polio were the absence of objective sensory

findings in the presence of flaccid motor paralysis, and stated that in FDR's case "we find no reason to question the diagnostic accuracy of poliomyelitis and wish to put this debate to rest." In their well-known monograph on GBS and in relation with FDR's case, Steinberg and Parry<sup>24</sup> wrote that "however, this is not a consensus position; most people familiar with GBS feel that [FDR's] illness was much more typical of polio than GBS. As with all revisions of history, the truth will probably never be known." Goldman and his group rechecked their data, concluding that according to the clinical data, the most likely diagnosis in FDR's case remained GBS.<sup>6,25</sup>

As noted above, FDR presented early and relatively persistent manifestations of the sensory system, namely: *i*) severe back and leg pain; *ii*) leg numbness; *iii*) sensitivity



**Figure 6.** A) Joseph Stalin, Franklin D. Roosevelt, and Winston Churchill at the Tehran Conference (December, 1943). B) Winston Churchill, Franklin D. Roosevelt, and Joseph Stalin at the Yalta Conference (February, 1945). Note the apparent physical deterioration of Roosevelt over the 14 months between both photos. Images taken from Roosevelt Library in Hyde Park,<sup>13</sup> where it is stated that these pictures are in the public domain and can be used without further permission.

to touch so painful that he could not stand the pressure of his bedclothes; *iv*) acute distress with even the movement of the slightest breeze across the skin; and *v*) in his own words (see Supplementary material 2), “all muscles from the hip down were extremely sensitive to the touch and I had to have the knees supported by pillows.” Although sensory examination was not performed, to the best of our knowledge all these manifestations indicate a participation of the sensory system in the disease. Furthermore, characteristics of the positive sensory manifestations point to neuropathic pain, which is characteristic of any early GBS subtype, occurring in 35% of cases.<sup>26-28</sup> In paralytic polio there may be signs of meningeal irritation and muscle soreness or even muscle pain, but neither skin numbness nor neuropathic pain has been reported.<sup>29,30</sup> Leaving aside other considerations,<sup>15,25</sup> the reported sensory semiology indicates that FDR suffered from GBS. The “consensus position” alluded by Steinberg and Parry<sup>24</sup> can be rebutted alluding to the aphorism by Galileo Galilei: “In questions of science, the authority of a thousand is not worth the humble reasoning of a single individual.”<sup>31(p129)</sup>

## 2. Hypertensive heart disease, left cardiac failure, and terminal cerebrovascular stroke

Symptomatic hypertensive cardiovascular disease culminating in fatal stroke occurred in the last 16 months of FDR's life. A detailed clinical description of this period is available in the paper by Dr Howard Bruenn,<sup>19</sup> based upon his own clinical notes, written 15 years after the death of the President, and with the permission of the latter's family members. In spite of this, the paper led to ethical controversies,<sup>32</sup> which we understand to be entirely unjustified. In fact, the only medical source of information on the last President's illness is that of Bruenn, given that “the records disappeared right after his death. Since Dr McIntire was one of three people with access to the safe, historians accused Dr McIntire of destroying FDR's medical records in order to hide his misdiagnosis and mismanagement of the president's case.”<sup>17</sup> As reported by Bruenn, death was most probably the result of a massive cerebral hemorrhage. There is no rational basis

to suggest that this last event was due to metastatic melanoma.<sup>33</sup> By the express wish of Eleanor Roosevelt, no autopsy was performed.

## Conclusions

Franklin Delano Roosevelt was the only American president to serve four terms, under very difficult circumstances. He overcame the calamities of his own illnesses. First, middle-age acute ascending paralysis, classed at the time as paralytic polio but which was in fact GBS; in any case, he contributed to developing rehabilitation programs and research projects on poliomyelitis. And second, despite suffering severe hypertensive cardiac disease during the last months of life, his presidential activity always remained immutable. The day after FDR's death, the *New York Times* printed an editorial defining his legacy, from which the following paragraph is extracted: “It will honor him above all else because he had the vision to see clearly the supreme crisis of our times and the courage to meet that crisis boldly. Men will thank God, on their knees, a hundred years from now, that Franklin D. Roosevelt was in the White House.”<sup>32</sup> Certainly, such wise words remain true today.

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## Conflicts of interest

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