

# Hidden blood loss in minimally invasive surgery for osteoporotic vertebral fractures.

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## Research Article

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# Abstract

## Purpose

Minimally invasive surgery (MIS) of the spine prevents the collapse of osteoporotic vertebral fractures (OVF) with lower complication and bleeding rates than open surgery. However, the possibility of hidden blood loss (HBL) has been recently described. This study aimed to estimate the postoperative impact of HBL in patients undergoing MIS for OVF.

## Methods

This was a retrospective study of a series of patients. Those with pathological fractures, using anticoagulant or antiplatelet therapy, with severe anemia (hemoglobin [Hb] <9 g/dL), who had received a transfusion before surgery, or with hematological disorders were excluded. A descriptive analysis of recorded variables was performed, and total blood volume (TBV), total bleeding (TB), HBL, and Hb drop were calculated. This was followed by a comparative analysis between HBL and the variables of hospital stay and postoperative evolution.

## Results

A total of 40 patients were included, eight men and 32 women, with a mean age of 76.6 years. The mean HBL was 682.5 mL. HBL greater than 500 mL was related to a higher probability of torpid postoperative evolution ( $p = 0.045$ ) and a longer hospital stay ( $p = 0.067$ ). A higher HBL was observed in surgeries of greater technical complexity and longer surgical time.

## Conclusion

Although MIS techniques have shown less intraoperative bleeding than open surgery, HBL should be diagnosed because it is associated with a torpid evolution. The use of a diagnostic and therapeutic algorithm may help minimize its impact.

## Introduction

Osteoporotic vertebral fractures (OVF) are generally diagnosed in patients older than 60 years of age with a variety of comorbidities and low bleeding tolerance that could decompensate them, something to be considered if the fracture requires surgery due to the risk of collapse [1].

Minimally invasive surgery (MIS) techniques in the spine have been shown to prevent the collapse of OVF, with a low complication rate [2]. One of the advantages of these techniques is lower intraoperative

bleeding compared to open surgery, considering that MIS does not require an ample dissection of the paravertebral musculature [3, 4].

In recent studies, the term “hidden blood loss” (HBL) has been coined to refer to the loss of blood diffused into tissues and lost through hemolysis [4]. Postoperative recovery can be seriously affected by this bleeding, increasing the rate of transfusions and medical complications and thus increasing hospital stay [5]. However, most studies on MIS quantify intraoperative bleeding but do not consider the possibility of HBL.

We have clinically detected that some of our patients have a torpid evolution after MIS for OVF. Therefore, we performed a study to estimate the impact of HBL in the postoperative period. We also aimed to formulate a postoperative management proposal for early diagnosis to help minimize its consequences.

## Methods

This was a retrospective study of clinical data from patients who underwent surgery for OVF using MIS techniques between June 1, 2020, and November 30, 2021. Only cases in which a control blood analysis was performed 24–48 hours after surgery were included. All surgeries were performed by the same specialized surgeon in our unit. The most appropriate surgical technique was decided according to the computer tomography fracture morphology based on the AO Spine—Spine Section of the German Society for Orthopaedics and Trauma (DGOU) Osteoporotic Fracture Classification System [6]: vertebroplasty, percutaneous fixation one level above and one level below (1L-1L) cemented or uncemented, percutaneous fixation two levels above and two levels below (2L-2L) cemented or uncemented, and combinations of these techniques.

We excluded all patients with pathological fractures, using anticoagulant or antiplatelet therapy (only 100 mg acetylsalicylic acid was accepted, a drug that was withdrawn before surgery), with severe anemia (considered hemoglobin [Hb] <9 g/dL), who had received a transfusion before surgery, or with hematological disorders such as thrombopenia and coagulation abnormalities.

Data were collected regarding sex, age, body mass index (BMI), cardiovascular risk factors (CVRF, considered dyslipidemia, arterial hypertension, or diabetes mellitus), American Society of Anesthesiologists (ASA) anesthetic risk classification [7], type of surgery, days of hospital stay (considering the day of discharge when the patient resumed independent ambulation), and postoperative evolution (a torpid evolution was defined as delayed ambulation due to issues such as pain, poor general condition, nausea, desaturation, sustained arterial hypotension, orthostatic dizziness, or loss of appetite). Total blood volume (TBV), total bleeding (TB), HBL, and Hb drop were calculated according to the following equations.

The formulas used in earlier studies were applied for the calculation of HBL [8]:

$$\text{HBL (mL)} = \text{TB (mL)} - \text{measured blood loss (mL)}$$

Since the surgical aspirator used measures a minimum of 100 mL, accurately recording intraoperative measured bleeding was not possible, given that for a high percentage of patients, it did not achieve that level. For this reason, to carry out the necessary calculations and homogenize the results, we assumed that the intraoperative measured bleeding reached 100 mL for all patients, considering that bleeding is also collected in compresses.

TB was estimated using Gross et al.'s method [9], based on hematocrit levels before and after surgery (24–48 hours):

$$TB \text{ (mL)} = TBL \text{ (L)} \times \frac{\text{preoperative hematocrit (\%)} - \text{postoperative hematocrit (\%)}}{\text{mean hematocrit (\%)}} \times 1000$$

The method described by Nadler et al. [10] was used to calculate the patient's TBV.

$$TBV \text{ (L)} = k_1 \times \text{height(m)}^3 + k_2 \times \text{weight (kg)} + k_3$$

where  $k_1 = 0.3669$ ,  $k_2 = 0.03219$ , and  $k_3 = 0.6041$  for men, and  $k_1 = 0.3561$ ,  $k_2 = 0.03308$ , and  $k_3 = 0.1833$  for women.

The preoperative and postoperative Hb (after 24 or 48 hours, taking as reference the lowest value) were used to calculate the Hb drop, according to the equation used by Chen et al. [4]:

$$\text{Hb drop (g/L)} = \text{preoperative Hb (g/L)} - \text{postoperative Hb (g/L)}$$

A descriptive analysis of the results was performed using IBM SPSS version 25 statistics software, expressing the results as mean  $\pm$  standard deviation for quantitative variables, and absolute values and percentages for qualitative variables. A comparative analysis was performed between the calculated HBL (<500 mL vs.  $\geq$ 500 mL) and the variables of hospital stay (days) and postoperative evolution (torpid vs. favorable). Student's t-test was used for the comparative analysis between hospital stay and HBL, and Pearson's Chi-square test was used to compare post-surgical evolution and HBL. A statistical significance value of 0.05 was assumed.

## Results

Only 40 patients met the inclusion criteria because routine postoperative laboratory tests were not regularly carried out before our knowledge of HBL. Table 1 summarizes the demographic characteristics of the sample. Table 2 shows the MIS technique used to treat OVF and its relative frequency.

Table 1  
Demographic data of the patient series

	<b>Men</b> <i>n</i> = 8 (20.0%)	<b>Women</b> <i>n</i> = 32 (80.0%)	<b>Total</b> <i>n</i> = 40
<b>Age</b>	79.8 ± 8.8	75.9 ± 7.1	76.7 ± 7.5
<b>CVRF</b>	7 (87.5%)	29 (90.6%)	36 (90.0%)
<b>BMI</b>	28.7 ± 4.9	26.6 ± 3.9	27.0 ± 4.1
<b>Normal weight</b> (BMI 18.5–24.9 kg/m <sup>2</sup> )	3 (37.5%) 2 (25.0%)	11 (34.4%) 17 (53.1%)	14 (35.0%) 19 (47.5%)
<b>Overweight</b> (BMI 25–29.9 kg/m <sup>2</sup> )	3 (37.5%)	4 (12.5%)	7 (17.5%)
<b>Obese</b> (BMI >30 kg/m <sup>2</sup> )			
<b>ASA II</b>	7 (87.5%)	28 (87.5%)	35 (87.5%)
<b>III</b>	1 (12.5%)	4 (12.5%)	5 (12.5%)

Table 2  
Frequency of the different MIS techniques used

<b>MIS techniques</b>	<b>Total</b> <i>n</i> = 40
Vertebroplasty	2 (5.0%)
1L-1L cementless fixation	10 (25.0%)
2L-2L cementless fixation	9 (22.5%)
2L-2L cemented fixation	7 (17.5%)
1L-1L cementless fixation + vertebroplasty	3 (7.5%)
1L-1L cemented fixation + vertebroplasty	1 (2.5%)
2L-2L cementless fixation + vertebroplasty	7 (17.5%)
2L-2L cemented fixation + vertebroplasty	1 (2.5%)

Table 3 summarizes the data regarding Hb drop, TBV, TB, and HBL according to the MIS technique employed. The HBL calculated for cementless 1L-1L fixation technique combined with vertebroplasty had a negative result of -46.4 mL because a TB of less than 100 mL was calculated.

Table 3  
Hb drop, TBV, TB, and HBL

MIS technique	Hb drop (g/dL)	TBV (L)	TB (mL)	HBL (mL)
Vertebroplasty	1.3 ± 1.2	3.5 ± 0.3	488.5 ± 565.3	388.5 ± 565.3
1L-1L cementless fixation	1.9 ± 1.6	4.2 ± 0.5	669.1 ± 582.0	569.1 ± 582.0
2L-2L cementless fixation	2.4 ± 1.3	4.3 ± 0.7	765.7 ± 362.0	665.7 ± 362.0
2L-2L cemented fixation	2.7 ± 1.2	4.0 ± 0.2	912.1 ± 336.9	812.1 ± 336.9
1L-1L cementless fixation + vertebroplasty	0.3 ± 0.6	4.0 ± 0.2	53.6 ± 220.0	-46.4 ± 220.0
1L-1L cemented fixation + vertebroplasty	2.9 ± 0.0	4.0 ± 0.3	938.6 ± 0.0	838.6 ± 0.0
2L-2L cementless fixation + vertebroplasty	2.9 ± 1.6	4.0 ± 0.3	1108.7 ± 705.7	1008.7 ± 705.7
2L-2L cemented fixation + vertebroplasty	4.3 ± 0.0	3.2 ± 0.0	1493.3 ± 0.0	1393.26 ± 0.0
		4.2 ± 0.5		
		3.6 ± 0.0		
Total mean	2.3 ± 1.5	4.1 ± 0.5	782.5 ± 542.4	682.5 ± 542.4

Data related to hospital stay and torpid postoperative evolution, segmented by HBL <500 mL and ≥500 mL, are shown in Table 4. An HBL ≥500 mL was statistically significantly associated with a higher frequency of cases that showed a torpid evolution during the postoperative period.

Table 4  
Hospital stay and evolution by calculated HBL

	HBL <500 mL <i>n</i> = 15 (37.5%)	HBL ≥500 mL <i>n</i> = 25 (62.5%)	Total <i>n</i> = 40	<i>p</i> -value
<b>Hospital stay (days)</b>	3.5 ± 1.8 [range 1–9]	5.1 ± 3.4 [range 1–15]	4.5 ± 3.0 [range 1–5]	0.067
<b>Torpid postoperative evolution</b>	2 (13.3%)	11 (44.0%)	13 (32.5%)	<b>0.045</b>

## Discussion

The incidence of OVF has increased with the aging population [11]. Patients with OVF may experience pain, spine deformity, functional disability, depression, decreased quality of life and associated increased

risk of adjacent fractures and mortality [2].

The development of minimally invasive techniques for approaching these fractures has made it possible to indicate surgery in patients whose age and comorbidities contraindicate open surgery. Thus, the mean age of our series of patients was 76.7 years. These patients had a high percentage of CVRF and were markedly overweight. Their age was similar to the patients of Cao et al. (75 years) [5] and Wu et al. (71 years) [12] and younger than those of Cai et al. (88.14 years) [1].

The mean HBL calculated in our series was 682.5 mL. Analyzing the results according to the technique used, a higher calculated HBL was observed in longer procedures. Thus, cemented 2L-2L fixation combined with vertebroplasty showed the highest calculated HBL. In contrast, vertebroplasty, which is usually a relatively fast procedure, had a calculated HBL of 388.5 mL. Similarly, Wu et al. [12] estimated an HBL of 256 mL in patients with one-level fractures treated by kyphoplasty.

For fractures treated by percutaneous 1L-1L fixation, an HBL of 569.1 mL was calculated, higher than that found by Chen et al. (240mL) [4]. This difference may be explained because the patients in that series were young, with traumatic fractures, a mean age of 45.3 years, and a BMI of 23.1.

Statistically significant differences existed in postoperative outcomes according to HBL. Patients with a higher calculated HBL showed a torpid postoperative evolution in a more significant number of patients ( $p = 0.045$ ). On the other hand, the mean hospital stay did not vary significantly when the data were segmented by HBL, although it was somewhat longer in the group of patients with a calculated HBL of  $\geq 500$  mL.

As this study shows, post-surgical bleeding and its possible consequences in elderly patients are unavoidable. In the event of a torpid postoperative evolution, analyzing the drop in Hb is crucial, not only the absolute value in postoperative control blood tests. The absolute Hb value may be in range postoperatively and not recommend blood transfusion (according to international guidelines, it would only be indicated when Hb is below 7 g/dL [13]), but a drop of more than three points could have an impact on the patient's clinical course. For example, suppose a patient is admitted for OVF with a preoperative Hb of 12 g/dL, and the Hb drops to 8 g/dL after surgery. In that case, although this Hb would not indicate a red blood cell transfusion, such a significant drop is likely to have clinical consequences on the patient's outcome. Similar to hip surgery [14], we consider it advisable to adapt the transfusion threshold to each case.

Some authors suggest using preoperative intravenous tranexamic acid to minimize the rate of surgical bleeding, and thus its consequences, in patients with percutaneously treated thoracolumbar fractures [15]. However, its use is still under discussion, and its indication is off-label.

After analyzing our results, we have developed the following protocol for early detection and treatment of HBL after MIS for OVF (Diagram 1). We believe it could be used in clinical practice to minimize the effects of HBL and help discard other causes of bleeding.

## Diagram 1. *Protocol for early detection and treatment of hidden blood loss*

Our study has some limitations. First, this was a retrospective observational study with a limited series of cases. However, it was the first Spanish series of patients undergoing surgery for OVF using MIS techniques to study HBL and the first to propose a diagnostic and therapeutic algorithm. The calculation of HBL assumed that the measured bleeding was 100 mL, which could have altered the results, given that this value was not reached in most cases. However, other authors, such as Cao et al. [5], ignored intraoperative measured bleeding in their calculations. Furthermore, importantly, only those patients who had a blood test 24–48 hours after surgery (according to the defined criteria) were included, and therefore the results obtained may have overstated the overall importance of HBL in this type of surgery. Finally, our population's advanced mean age may have resulted in a higher calculated HBL due to an increased tendency to global bleeding.

## Conclusions

- Although MIS techniques for OVF have shown less intraoperative bleeding than open surgery, intraoperative HBL has not always been recognized. However, HBL should be pro-actively considered since it is associated with a poor postoperative outcome.
- The detection of a significant drop in hemoglobin (despite postoperative hemoglobin within normal range that does not indicate a blood transfusion) may reflect a higher HBL and, consequently, predict an unfavorable postoperative outcome.
- The use of an algorithm for early diagnosis and management of HBL may help minimize its impact in elderly patients.

## Declarations

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Informed consent: Verbal informed consent was obtained from all participants included in the study.

Data availability: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions: Conceptualization: Sara Burguet Girona; Methodology: Sara Burguet Girona, Victor Martin-Gorgojo; Formal analysis and investigation: Victor MartinGorgojo; Writing – original draft

preparation: Victor Martin-Gorgojo; Writing – review and editing: Sara Burguet Girona, Sonia Muñoz Donat; Supervision: Sara Burguet Girona, Sonia Muñoz Donat.

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## Supplementary Files

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- [Diagram1.jpg](#)