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フレイル患者では，成人脊柱変形に対する手術後の良好なアウトカムのために，より近位の脊椎インストゥルメンテーションが必要である

Frail patients require instrumentation of a more proximal vertebra for a successful outcome after surgery for adult spine deformity

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Aims:
The aim of this study was to investigate the impact of the level of upper instrumented vertebra (UIV) in frail patients undergoing surgery for adult spine deformity (ASD).

Methods:
Patients with adult spinal deformity who had undergone T9-to-pelvis fusion were stratified using the ASD-Modified Frailty Index into not frail, frail, and severely frail categories. ASD was defined as at least one of: scoliosis ≥ 20°, sagittal vertical axis (SVA) ≥ 5 cm, or pelvic tilt ≥ 25°. Means comparisons tests were used to assess differences between both groups. Logistic regression analyses were used to analyze associations between frailty categories, UIV, and outcomes.

Results:
A total of 477 patients were included (mean age 60.3 years [SD 14.9], mean BMI 27.5 kg/m2 [SD 5.8], mean Charlson Comorbidity Index [CCI] 1.67 [SD 1.66]). Overall, 74% of patients were female (n = 353), and 49.6% of patients were not frail (237), 35.4% frail (n = 169), and 15% severely frail (n = 71). At baseline, differences in age, BMI, CCI, and deformity were significant (all p = 0.001). Overall, 15.5% of patients (n = 74) had experienced mechanical complications by two years (8.1% not frail [n = 36], 15.1% frail [n = 26], and 16.3% severely frail [n = 12]; p = 0.013). Reoperations also differed between groups (20.2% [n = 48] vs 23.3% [n = 39] vs 32.6% [n = 23]; p = 0.011). Controlling for osteoporosis, baseline deformity, and degree of correction (by sagittal age-adjusted score [SAAS] matching), frail and severely frail patients were more likely to experience mechanical complications if they had heart failure (odds ratio [OR] 6.6 [95% CI 1.6 to 26.7]; p = 0.008), depression (OR 5.1 [95% CI 1.1 to 25.7]; p = 0.048), or cancer (OR 1.5 [95% CI 1.1 to 1.4]; p = 0.004). Frail and severely frail patients experienced higher rates of mechanical complication than 'not frail' patients at two years (19% [n = 45] vs 11.9% [n = 29]; p = 0.003). When controlling for baseline deformity and degree of correction in severely frail and frail patients, severely frail patients were less likely to experience clinically relevant proximal junctional kyphosis or failure or mechanical complications by two years, if they had a more proximal UIV.

Conclusion:
Frail patients are at risk of a poor outcome after surgery for adult spinal deformity due to their comorbidities. Although a definitively prescriptive upper instrumented vertebra remains elusive, these patients appear to be at greater risk for a poor outcome if the upper instrumented vertebra is sited more distally.

目　的：
本研究の目的は，成人脊柱変形（ASD）の手術を受けたフレイル患者における固定上位端椎（UIV）レベルの影響を検討することである．

方　法：
ASD-Modified Frailty Index を用いて，T9-骨盤の固定術を受けた ASD 患者を非フレイル，フレイル，重度のフレイルに層別化した．側弯 20° 以上，sagittal vertical axis（SVA）5 cm 以上，pelvic tilt 25° 以上の少なくとも一つに当てはまることを ASD と定義した．平均値を比較する検定を用いて 3 群間の差を評価した．ロジスティック回帰分析を用いてフレイルカテゴリー，UIV，アウトカム間の関連を解析した．

結　果：
477 例を本研究の対象とした（平均年齢 60.3 歳［標準偏差 14.9］，平均 BMI 27.5 kg/m^2［標準偏差 5.8］，平均 Charlson Comorbidity Index［CCI］1.67［標準偏差 1.66］）．全体として，患者の 74% は女性で（353 例），49.6% は非フレイル（237 例），35.4% はフレイル（169 例），15% は重度のフレイル（71 例）であった．ベースライン時の年齢，BMI，CCI，変形に有意差が認められた（すべて $p = 0.001$）［共分散分析］．全体として，患者の 15.5%（74 例）で 2 年時点までに機械的合併症が発現した（非フレイル 8.1%［36 例］，フレイル 15.1%［26 例］，重度のフレイル 16.3%［12 例］，$p = 0.013$）．再手術にも群間差が認められた（20.2%［48 例］対 23.3%［39 例］対 32.6%［23 例］，$p = 0.011$）［χ^2 検定］．骨粗鬆症，ベースラインの変形，矯正の程度（sagittal age-adjusted score［SAAS］でマッチさせた）で補正したところ，心不全（オッズ比 6.6［95% 信頼区間 1.6 ～ 26.7］，$p = 0.008$），うつ病（オッズ比 5.1［95% 信頼区間 1.1 ～ 25.7］，$p = 0.048$），がん（オッズ比 1.5［95% 信頼区間 1.1 ～ 1.4］，$p = 0.004$）がみられる場合に，フレイルおよび重度のフレイル患者で機械的合併症が発現する割合が高かった［ロジスティック回帰分析］．2 年時点では，フレイルおよび重度のフレイル患者は，「非フレイル」患者よりも機械的合併症が発現する割合が高かった（19%［45 例］対 11.9%［29 例］，$p = 0.003$）［χ^2 検定］．重度のフレイルおよびフレイル患者についてベースラインの変形および矯正の程度で補正したところ，重度のフレイル患者は，UIV がより近位であるほど，2 年時点までに臨床的に重要な近位隣接椎間後弯変形や近位固定隣接障害または機械的合併症が発現する割合が低下した．

結　論：
フレイル患者は，併存疾患のために ASD の手術後にアウトカム不良となるリスクが高い．UIV を決定する指針は依然として明確ではないが，これらの患者は UIV がより遠位にある場合にアウトカム不良となるリスクが高まると思われる．

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Table II. Surgical factor and postoperative outcome comparisons.

Variable	Not frail	Frail	Severely frail	p-value
Mean EBL, ml (SD)	1,064.1 (1,202.2)	1,012.7 (1,150.6)	1,141.7 (1,297)	0.724*
Mean surgical time, mins (SD)	352.2 (134.3)	329.1 (124)	365.3 (136.5)	0.061*
Mean LOS, days (SD)	6.7 (3.9)	7.2 (4)	7.1 (3.2)	0.400*
Mean posterior levels fused, n (SD)	7.7 (1.51)	7.7 (1.47)	7.9 (1.50)	0.795*
Mean interbody fusion levels, n (SD)				
ALIF	2.2 (1.52)	1.8 (1.02)	1.9 (1.34)	0.346*
TLIF/PLIF	2.6 (0.68)	2.3 (0.58)	2.5 (0.54)	0.365*
Osteotomy performed, n (%)	132 (55.6)	94 (55.9)	39 (54.5)	0.980†
Postoperative deformity correction by sagittal age-adjusted score, n (%)				0.889†
Matched	70 (29.6)	57 (33.5)	24 (34.2)	
Under-corrected	55 (23.2)	36 (21.6)	17 (23.7)	
Over-corrected	112 (47.3)	76 (44.8)	30 (42.1)	
Implant failure, n (%)	19 (8.1)	26 (15.1)	12 (16.3)	0.035†
Reoperations, n (%)	48 (20.2)	39 (23.3)	23 (32.6)	0.011†
Mean ODI (SD)				
1 yr	20.6 (16.5)	30.2 (20.2)	43.3 (20.3)	< 0.001*
2 yrs	20.8 (16.8)	30.7 (19.6)	42.9 (22.8)	< 0.001*
Mean SRS-22 (SD)				
1 yr	3.81 (0.71)	3.52 (0.77)	3.07 (0.79)	< 0.001*
2 yrs	3.79 (0.73)	3.46 (0.78)	3.06 (0.82)	< 0.001*
Mean EQ-5D (SD)				
1 yr	0.84 (0.09)	0.80 (0.1)	0.74 (0.1)	< 0.001*
2 yrs	0.84 (0.09)	0.80 (0.09)	0.75 (0.11)	< 0.001*
Mean PI–LL, ° (SD)				
1 yr	1.55 (15.12)	5.08 (11.70)	6.29 (11.13)	0.014*
2 yrs	1.91 (13.98)	5.54 (12.12)	7.99 (13.04)	0.020*
Mean SVA, mm (SD)				
1 yr	22.4 (42.68)	38.98 (39.96)	55.30 (52.63)	< 0.001*
2 yrs	28.96 (46.66)	49.44 (49.08)	54.73 (52.93)	0.001*
Mean T1–PA, ° (SD)				
1 yr	16.28 (9.97)	18.82 (8.11)	20.30 (9.30)	0.004*
2 yrs	17.36 (9.43)	19.55 (8.58)	21.54 (9.46)	0.028*

*Analysis of covariance.
†Chi-squared test.
ALIF, anterior lumbar interbody fusion; EBL, estimated blood loss; EQ-5D, EuroQol five-dimension health questionnaire; LLIF, lateral lumbar interbody fusion; LOS, length of stay; ODI, Oswestry Disability Index; PI–LL, pelvic incidence-lumbar lordosis mismatch; PLIF, posterior lumbar interbody fusion; SRS-22, Scoliosis Research Society-22 item score; SVA, sagittal vertical axis; TLIF, transforaminal lumbar interbody fusion; T1–PA, T1–pelvic angle.

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