Successful Creation of Deployable Preoperative Predictive Risk Calculators for Individual Patient Event-Free Survivorship for Major Complications, Hospital Readmissions and Unplanned Surgery Following Adult Spinal Deformity (ASD) Surgery

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Few predictive models allow for proper patient selection, adjustment of invasiveness and patient frailty optimization to predict and reduce postop major complications, hospital readmissions, and unplanned surgeries following ASD surgery

The objective of this project is to create reliable predictive models for the occurrence and timing of Major Complications, Hospital Readmissions, and unplanned surgery following ASD surgery.

Methods

Retrospective analysis of two independent, prospective, multi-center ASD databases with identical fixed data fields

- European Spine Study Group (ESSG) Database
- International Spine Study Group (ISSG) Database

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Predictive modeling (Machine Learning)

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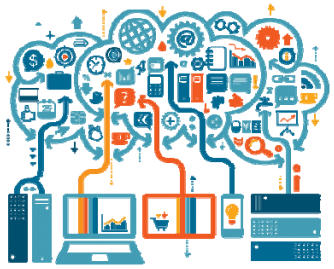

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Analyzed variables included:

a) patient characteristics
b) Surgical characteristics
c) Site-Fixed effects

We initially examined a set of 178 potential predictors:

a) Patient characteristics:

- a.1) Demographic data (age, gender, employment)
- a.2) Comorbidities
- a.3) Magnitude of the deformity (radiographic parameters)
- a.4) Baseline HRQoL (SF36v2, SRSr22 and ODI) and individual answers to these questionnaires

b) Surgical characteristics:

- b.1) Type of surgery (levels fused, osteotomies, interbody fusions, decompressions…)
- b.2) Immediate postoperative outcomes (blood loss and surgical time)

c) Site-Fixed effects:

- c.1) Surgeon
- c.2) Site

Variable selection and feature engineering was not performed before the training of the models to reduce the amount of pre-processing bias.

Three time-to-event outcomes were chosen as the main variables of interest:

a) Major complications (MC) during the first 730 days of follow-up.

b) Reintervention (ReInt) after failed ASD surgery during the first 730 days

c) Inhospital readmission (ReAd) directly caused by the surgery

A total of four models were defined for each of the three outcomes

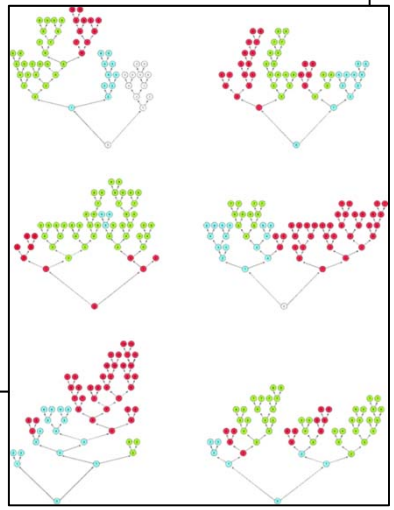
a) Preop information without surgeon nor hospital fixed-effects
b) Preop information with surgeon and hospital fixed-effects
c) Preop and inmediate postop (bleeding+surgical time) information without surgeon nor hospital fixed-effects
d) Preop and inmediate postop (bleeding+surgical time) information with surgeon and hospital fixed-effects

Training:

- Random survival forests were fitted to each of the 12 time-to-event prognosis models
- Interaction terms between predictors were handled by the underlying (random forest) algorithm
- No assumptions regarding the distribution nor the relationships of predictors were taken

Validation:

- External validation: A random 80/20 training/testing samples were used
- Internal validation: 5-fold cross validation was performed



Harrel's C statistic to assess the goodness of fit of the prognostic model

Results

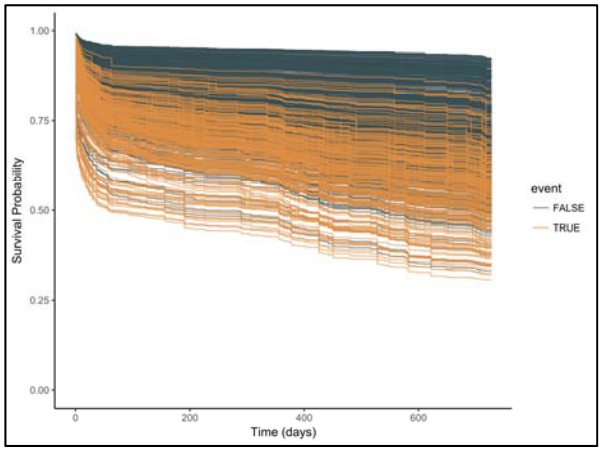
1612 surgical patients:

- 24 hospitals
- 5 countries
- 57 surgeons
- 730.5 days mean FU

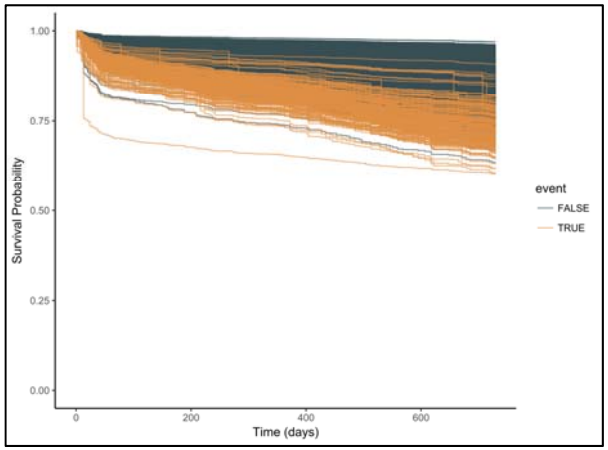
- Age: 56.69
- Length of hospitalization: 9.27 days
- Instrumented levels: 10.4
- 3CO: 22%

- Bleeding: 1480ml
- Surgical time: 339 minutes

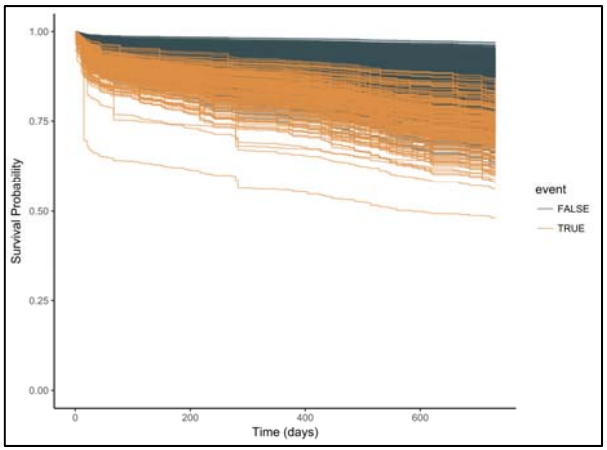
Variable	n	missing	mean	sd	median	min	max	se
Age	1612	0	56.69	17.37	61.35	18.05	86.64	0.4
Height cm	1612	0	162.81	10.99	162.6	63	195.6	0.3
Weight kgs	1612	0	71.5	17.41	68.92	35.9	173	0.4
Major Cobb Angle	1612	0	37.48	21.93	34.72	0	142	0.6
TL L Curve Degree	1612	0	33.18	19.54	29	0.8	123.7	0.5
Coronal Balance	1612	0	29.1	28.55	21.63	0	289	0.7
Leg Length Discrep	1612	0	6.48	6.24	5.25	0	68.83	0.2
Shoulder Height	1612	0	4.06	9.98	2.9	-40.5	77.6	0.3
Lordosis Gap	1612	0	21.44	20.81	21.04	-37.6	101.6	0.5
Lordosis top of L1 S1	1612	0	-40.93	21.41	-42	-103	30.7	0.5
Pelvic Incidence	1612	0	55.2	12.87	54.38	11.98	105	0.3
Pelvic Tilt	1612	0	23.06	10.92	23.17	-12.7	67.9	0.3
Sacral Slope	1612	0	32.07	11.69	32	-6.11	73	0.3
Sagittal Balance	1612	0	58.58	69.82	48.49	-117	326.5	1.7
T1 sagittal tilt	1612	0	-1.01	6.11	-2	-15.1	27.6	0.2
T2 T12	1612	0	38.52	19.61	37.5	-23.8	125.5	0.5
Length of Stay	1612	0	9.27	7.51	7	0	84	0.2
Blood Loss	1612	0	1480.1	1280.9	1200	0	12200	32
Surgical time	1612	0	339.5	144.78	330	22	855	3.6
Implant density	1612	0	1.71	0.27	1.72	0	2	0
Number of implants	1612	0	17.3	5.56	18.05	0	38	0.1
Number of levels	1612	0	10.4	4.34	10	0	25	0.1
Number of PLIF TLIF	1612	0	1	1.36	0	0	7	0
SPOs	1612	0	1.97	2.85	0	0	16	0.1
PSOs	1612	0	0.17	0.39	0	0	2	0
PVCRs	1612	0	0.05	0.26	0	0	5	0
3CO	1612	0	0.22	0.46	0	0	5	0



MC survival predictions (random forest model)



ReAd survival predictions (random forest model)



ReInt survival predictions (random forest model)

C-statistics:

Preop MC survival-free 67.7%
Postop MC survival-free 70.6%

C-statistics:

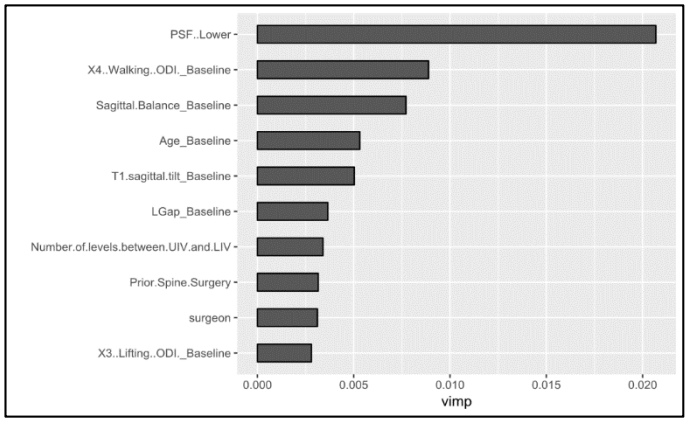
Preop ReAd survival free 62.7%
Postop ReAd survival free 64.6%

C-statistics:

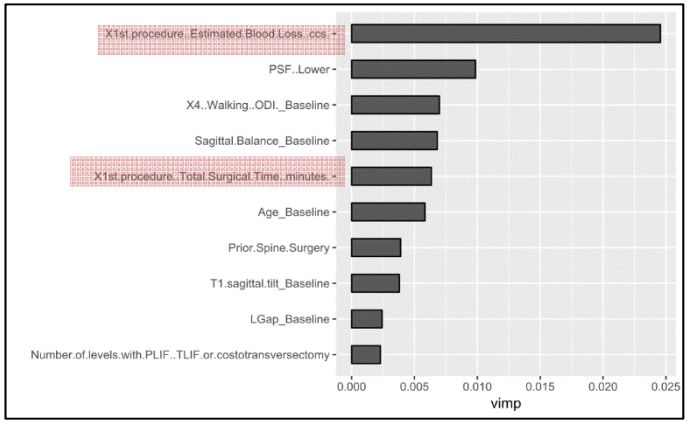
Preop ReInt survival free 61.6%
Postop ReInt survival free 63.3%

d) Preop and inmediate postop (bleeding+surgical time) information with surgeon and hospital fixed-effects

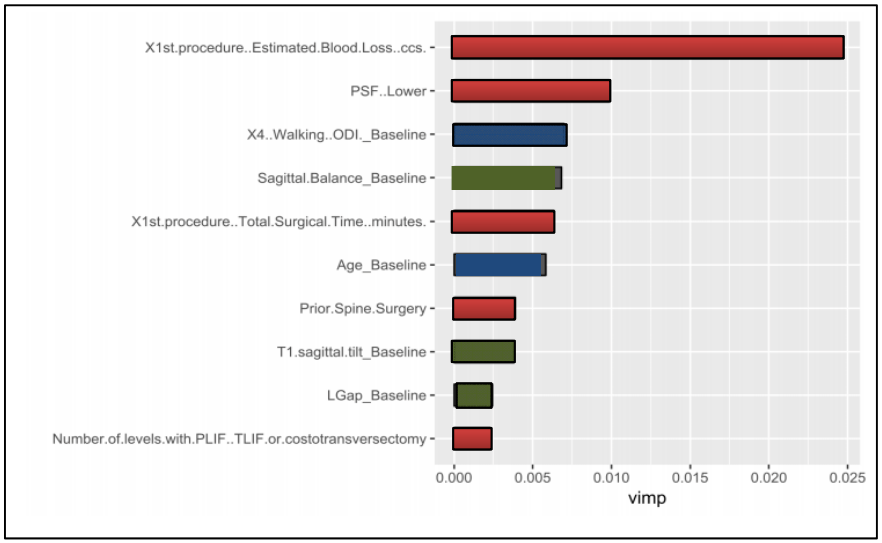
MC Preop (C-Test 67%)



MC PostOp (C-Test 70.6%)



- Surgical Invasiveness
- Frailty of Patient
- Deformity Magnitude



d) Preop and inmediate postop (bleeding+surgical time) information with surgeon and hospital fixed-effects

MC predictive model

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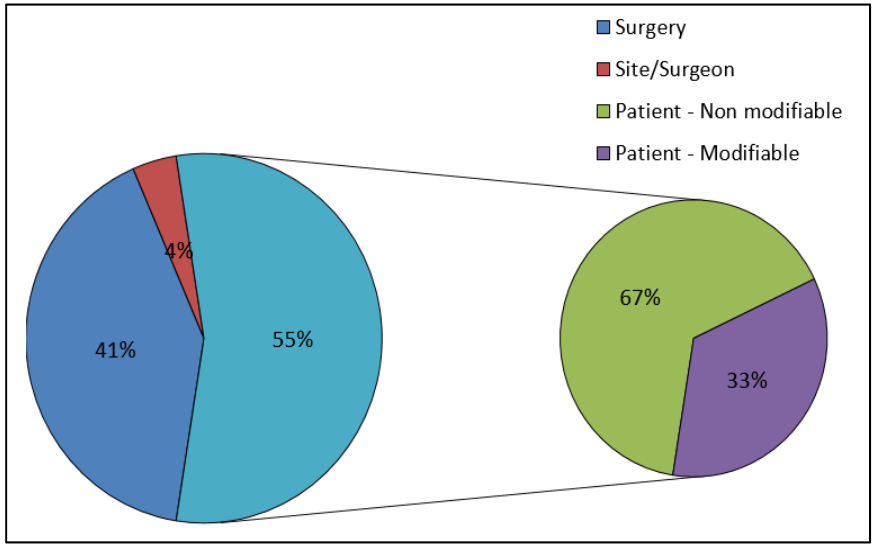
Patient-related factors, >1/3 of which are modifiable, account for 55% of the MC predictive model weight.
Surgeon and site represent 4%



Risk calculating models for event free MC, READMIT and UNPLAN following ASD surgery demonstrate that patient-related factors, >1/3 of which are modifiable, account for 55% of the MC predictive model weight. Surgeon and site represent 4% for MC, but are most relevant for READMIT and UNPLAN

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