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Incidence and Risk factors for Arthrogenic Muscle Inhibition (AMI) in Acute Anterior Cruciate Ligament Injuries

A Cross Sectional Study and Analysis of Associated Factors From the SANTI Study Group

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Introduction

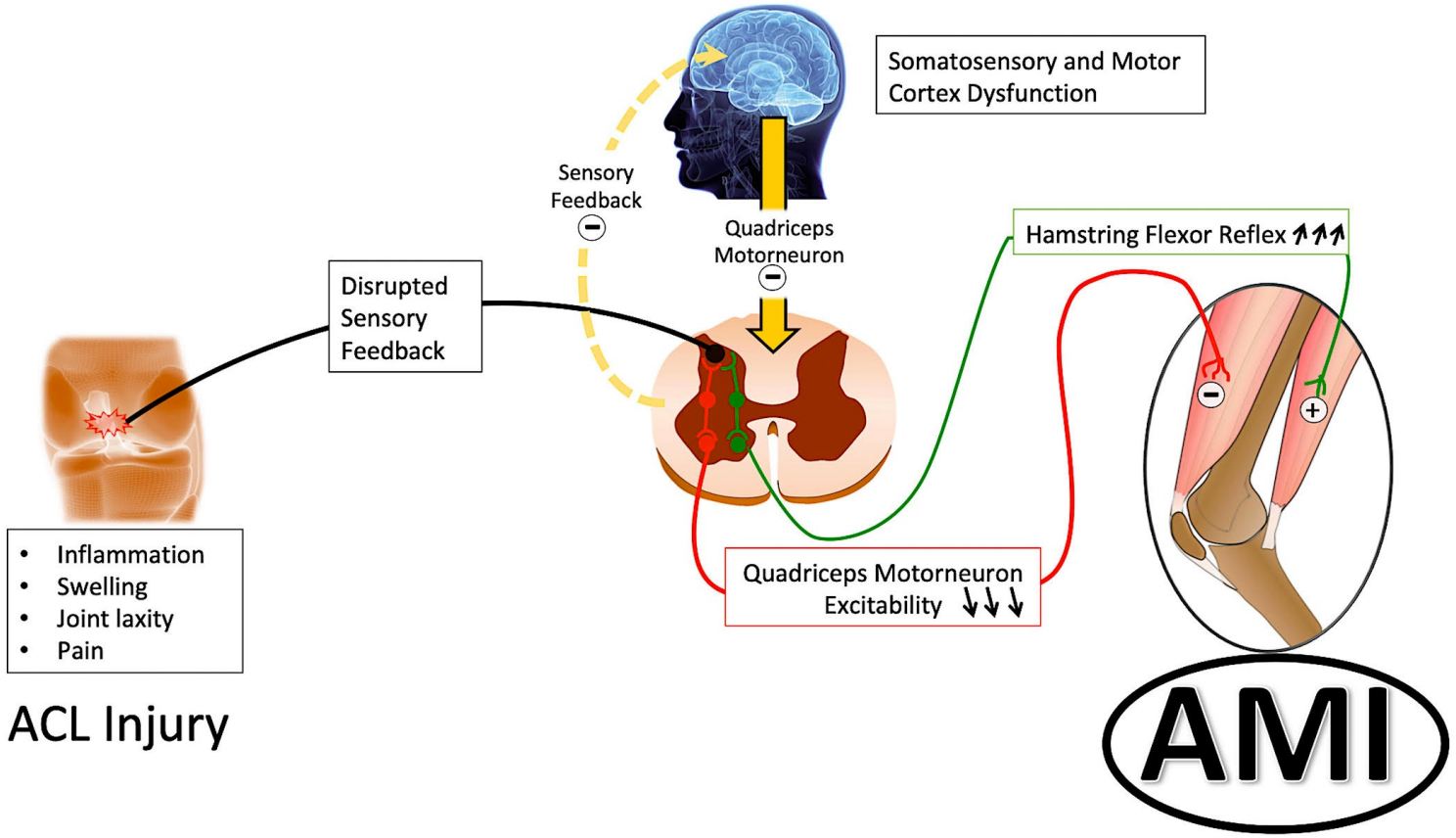
Arthrogenic muscle inhibition (AMI) is a frequent but underrecognized cause of quadriceps activation failure and knee extension deficit after acute knee injury and surgery

AMI is thought to represent a protective mechanism against further injury (by limiting movement and force transmission through the joint). However, it can also pose a major challenge to effective rehabilitation and cause significant morbidity

Sequalae of AMI include gait abnormality, quadriceps atrophy and weakness, poor function, dynamic instability, joint contracture, cyclops syndrome, persistent knee pain, proprioceptive deficits, impaired motor coordination, altered movement patterns and early osteoarthritis

Mechanism of AMI

Swelling and pain following injury results in changes in the discharge of articular sensory receptors and inhibitory signals at the spinal cord level resulting in altered spinal reflex excitability (affecting Group I nonreciprocal (Ib) inhibitory pathway, the flexion reflex and the gamma (γ)-loop), alteration in muscle resting motor thresholds, and abnormal cortical activity (intracortical inhibition and a requirement for greater frontal cortex theta-power in basic movement and joint position sense tasks) resulting in decreased quadriceps motorneuron excitability and increased hamstring flexor reflex



Study Aims

1. To use the recently described Sonnery-Cottet clinical classification of AMI to determine the incidence and spectrum of AMI following ACL Injury

2. To determine the inter- and intra-observer reliabilities of the classification system.

3. To investigate potentially important clinical factors for their association with the presence of AMI after ACL injury.

Prospective Cohort Study: Methods

Consecutive patients who presented with an acute ACL injury between October 2021 and February 2022 were considered for study inclusion. Patients were only excluded if they declined to participate in the study.

Eligible patients underwent a standardized physical examination at their first outpatient appointment. This included an assessment of quadriceps inhibition, identification of any extension deficits, grading of AMI and its reversibility according to the Sonnery-Cottet Classification (see next slide)

All patients participated in a standardized interview, completed forms for patient reported outcome measures (VAS pain score, subjective International Knee Documentation Committee (IKDC) score, Lysholm score , Knee Injury and Osteoarthritis Outcome Score (KOOS), Simple Knee Value (SKV) and pre-injury Tegner activity level) and underwent physical examination

For the purposes of this study, reversibility of grade 1a and 2a AMI, was defined as restoration of the patient's ability to normally contract the VMO (Sonnery-Cottet classification grade 0), and abolishment of extension deficit following participation in simple exercises aimed at abolishing AMI at the first out-patient appointment, respectively.

Sonnery-Cottet Classification of AMI

GRADE 0, normal VMO contraction

→

GRADE 1a, VMO contraction is inhibited but activation failure is reversible with simple exercises

→

GRADE 1b, as 1a but requires longer and specific rehabilitation programs

↓

GRADE 2a, VMO contraction is inhibited with an associated extension deficit due to hamstring contracture but activation failure and loss of range of motion is reversible with simple exercises

→

GRADE 2b, as 2a but refractory to simple exercises and longer and specific rehabilitation programs are required

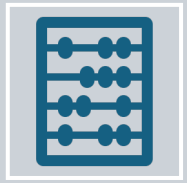
→

GRADE 3, chronic extension deficit that is irreducible without extensive posterior arthrolysis.

Key Statistical Analyses

Comparisons of data were made using the Chi squared test or Fisher exact test

Patient demographics, injury characteristics, and other potentially important factors were investigated for association with the presence of AMI using a Firth's penalized logistic regression model



Variables were included in the initial multivariate model if they were significantly associated with the dependent variable (AMI status) at a significance level of p=0.20 or if they were considered potentially important prognostic factors based on existing literature. The final model was the result of a manual backward stepwise selection of variables with a significance level of p=0.05.

Results

- A total of 300 consecutive patients were enrolled in the study.
- 56.7% (n=170) had features of AMI.
- The spectrum and incidence of different grades of AMI, stratified according to the Sonnery-Cottet classification, are reported in the adjacent Table
- There were no significant differences between those with/without AMI, with respect to age, gender distribution, BMI, side of injury or pre-injury Tegner activity level

AMI Grade	N (%)	95% CI
0	130 (43.3)	[37.7;48.9]
1A	73 (24.3)	[35.5;50.4]
1B	13 (4.3)	[3.7;11.6]
2A	62 (20.8)	[29.2;43.7]
2B	22 (7.3)	[7.9;18.0]

Excellent Inter-Observer Reliability of Classification

Parameters	KAPPA			Agreement	
	Kappa Coefficient (SE)	Kappa 95% CI	Kappa interpretation	Observed agreement	Observed disagreement
AMI grade	0.929 (0.034)	[0.862; 0.996]	Almost perfect agreement	100/104 (96.2 %)	4/104 (3.8 %)

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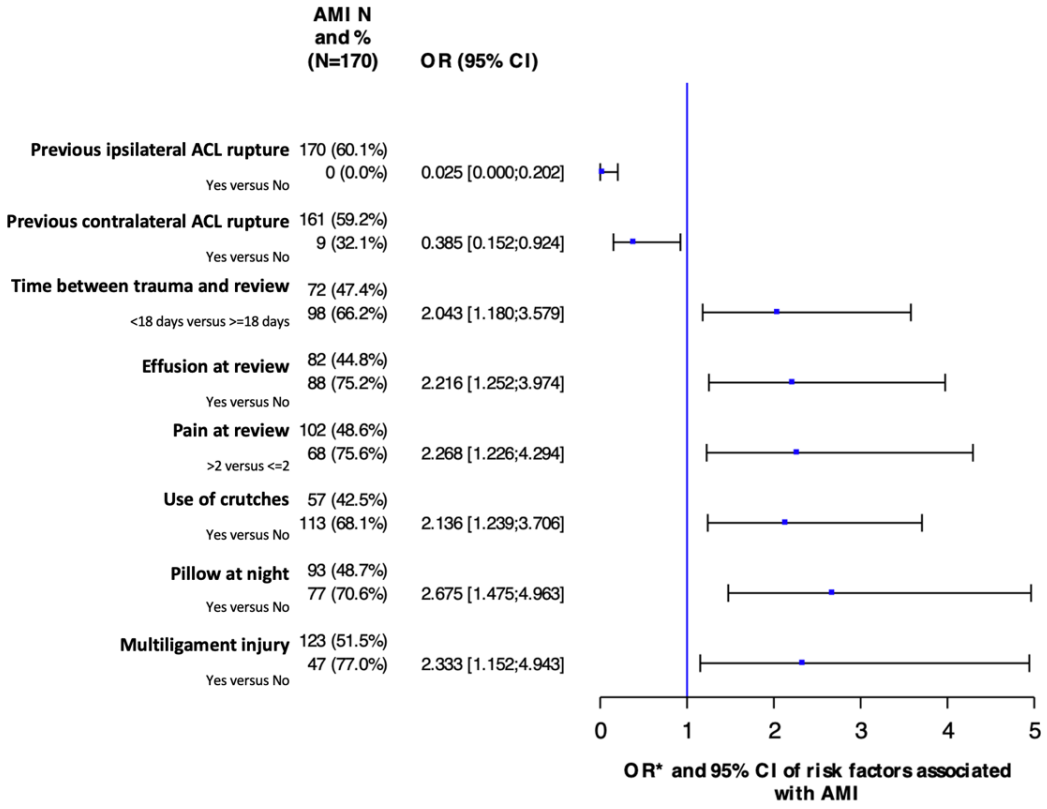
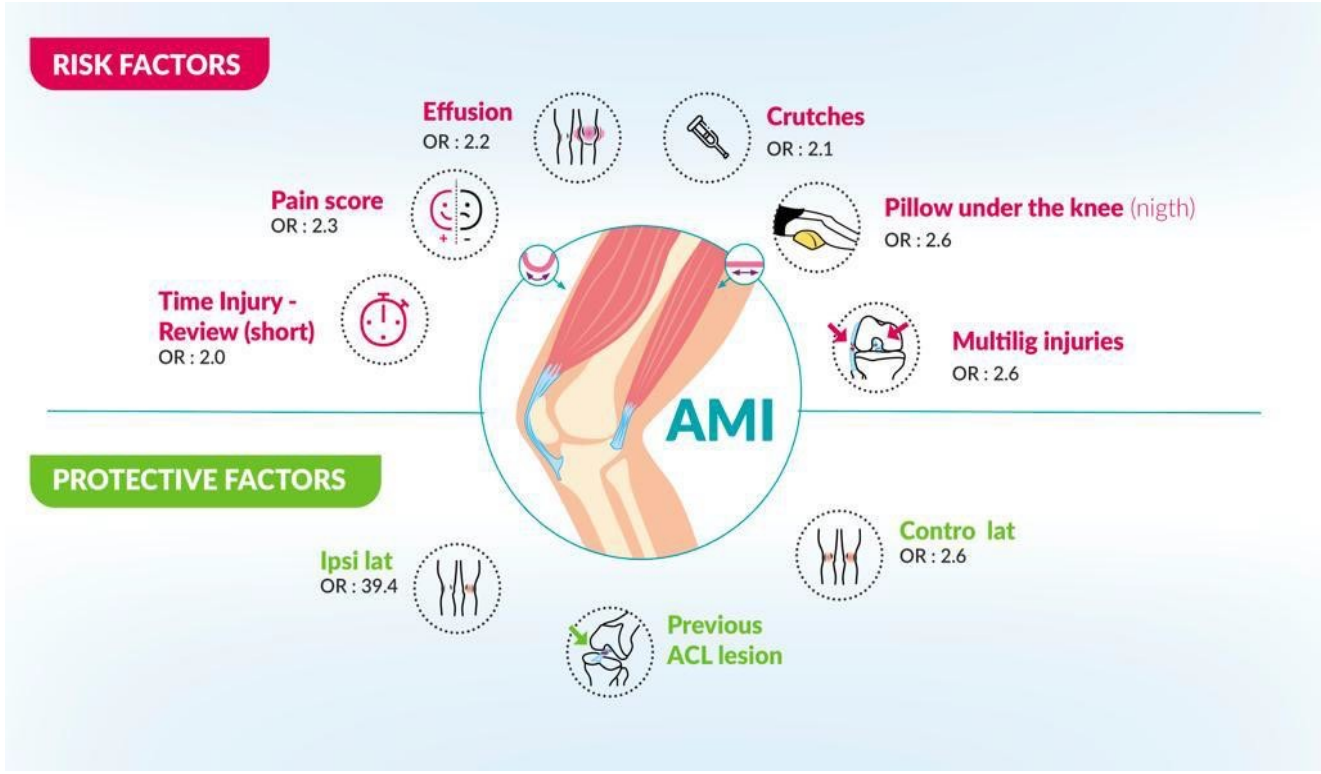
PROMS

Patients presenting with AMI displayed significantly inferior Lysholm, IKDC, SKV and KOOS scores than patients without AMI ($P < 0.0001$).

	Grade 0 (No AMI) (N=130)	Grades 1-2 (AMI) (N=170)	(N=300)	P value
Lysholm	74.3 ± 14.9	60.5 ± 7.4	66.5 ± 17.7	<.0001
IKDC	64.0 ± 15.6	49.3 ± 15.4	55.7 ± 17.1	<.0001
SKV	48.7 ± 20.5	35.7 ± 19.4	41.3 ± 20.9	<.0001
KOOS symptoms	82.9 ± 14.4	63.0 ± 21.1	71.6 ± 21.0	<.0001
KOOS pain	78.8 ± 13.2	66.2 ± 17.7	71.7 ± 17.1	<.0001
KOOS daily function	85.1 ± 13.5	69.4 ± 19.2	76.2 ± 18.7	<.0001
KOOS sport function	39.2 ± 28.3	23.2 ± 22.9	30.1 ± 26.5	<.0001
KOOS quality of life	46.7 ± 23.3	36.2 ± 22.2	40.7 ± 23.2	<.0001

Multivariate Analysis





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Conclusions

1

AMI occurs in over half of patients with acute anterior cruciate ligament injuries. When it occurs, it is easily reversible in the majority of patients with simple exercises targeted at abolishing AMI

2

The Sonnery-Cottet Classification of AMI demonstrates excellent inter-observer reliability

3

The presence of an effusion, high pain scores, multiligament injuries, use of crutches, and using a pillow as a support at night are significantly associated with the presence of AMI

4

Patients with a prior history of ipsilateral or contralateral ACL injury are at significantly lower risk of AMI than those with a first time ACL-injury.

Key References

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