

**OPIOID ANALGESICS  
(ANALGESICS – ANODYNES)**

# Pain

- Definition:

„subjective unpleasant sensory or emotional experience accompanied by real or potential damage of tissues, with motoric and vegetative responses“

# **Pain – types and classification**

A) by duration

B) according to pathophysiology

# Pain – types and classification

## A) According to length of experience

- 1) acute: sign of and disease, danger or damage to organism...
- 2) chronic: more than 3 months / **unusually long for a given disease or disorder**

# Pain – types and classification

## A) According to length of experience

- 1) acute: physiological sensory perception,
  - tissue damage,
  - mobilizes defensive forces of the organism in order to remove the inducing cause of the pain
  
- 2) chronic: pathological,
  - pain may persist even after the removal of the causes → difficult to determine whether the pain arose as a result of persistent pathological activity in the nerve endings in the periphery, or is the source of the CNS

# Pain – types and classification

## B) According to pathophysiology

1) nociceptive – irritation of nociceptors

Therapy: „analgesic ladder“ according WHO  
(see below; not used for aggressive procedure in the treatment for cancer or breakthrough pain)

2) neurological and neuropathic pain

Therapy: antidepressants and **anticonvulsants**  
(in combination with opioids or some muscle relaxants; neuroprotective vitamins – thiamine; antimigraine drugs from the group of the so-called triptans; antipsychotics = neuroleptics)

# Pain – types and classification

## B) According to pathophysiology

### 3) psychogenic pain

somatization, hypochondric and somatoform disorder

Therapy: psychopharmac drugs  
(antidepressants – TCA, SSRI, anxiolytics,  
antipsychotics)

# Special types of pain

## ■ neuralgia

sharp, paroxysmal pain, affects peripheral or cranial nerves (often the trigeminus, facialis) → after traumatological damage, compression, viral infects (herpetic), metabolic (DM)

## ■ pain in the chronic compression of peripheral nerves and nerve roots

hernia of the intervertebral discs, compression of the nerve in the spinal cord → pain + paresthesia, pain acquires a hot character



# Special types of pain

## ■ ischemic pain

due to disorders of blood circulation in the myocardium, smooth or skeletal muscle

## ■ migraine

migraine is characterized by attacks of pulsating, mostly unilateral headache lasting typically 4-72 hours with nausea, possible vomiting, photophobia and phonophobia, suffering from 12% of the adult population

# Special types of pain

## ■ phantom pain

surgically or traumatically removed parts of the human body, most commonly the lower limb or other parts of the body (ablation of the breast, as well as after the removal of the visceral organs - the colon);

apply pathophysiological influences peripheral, central and psychogenic;

## ■ breakthrough pain

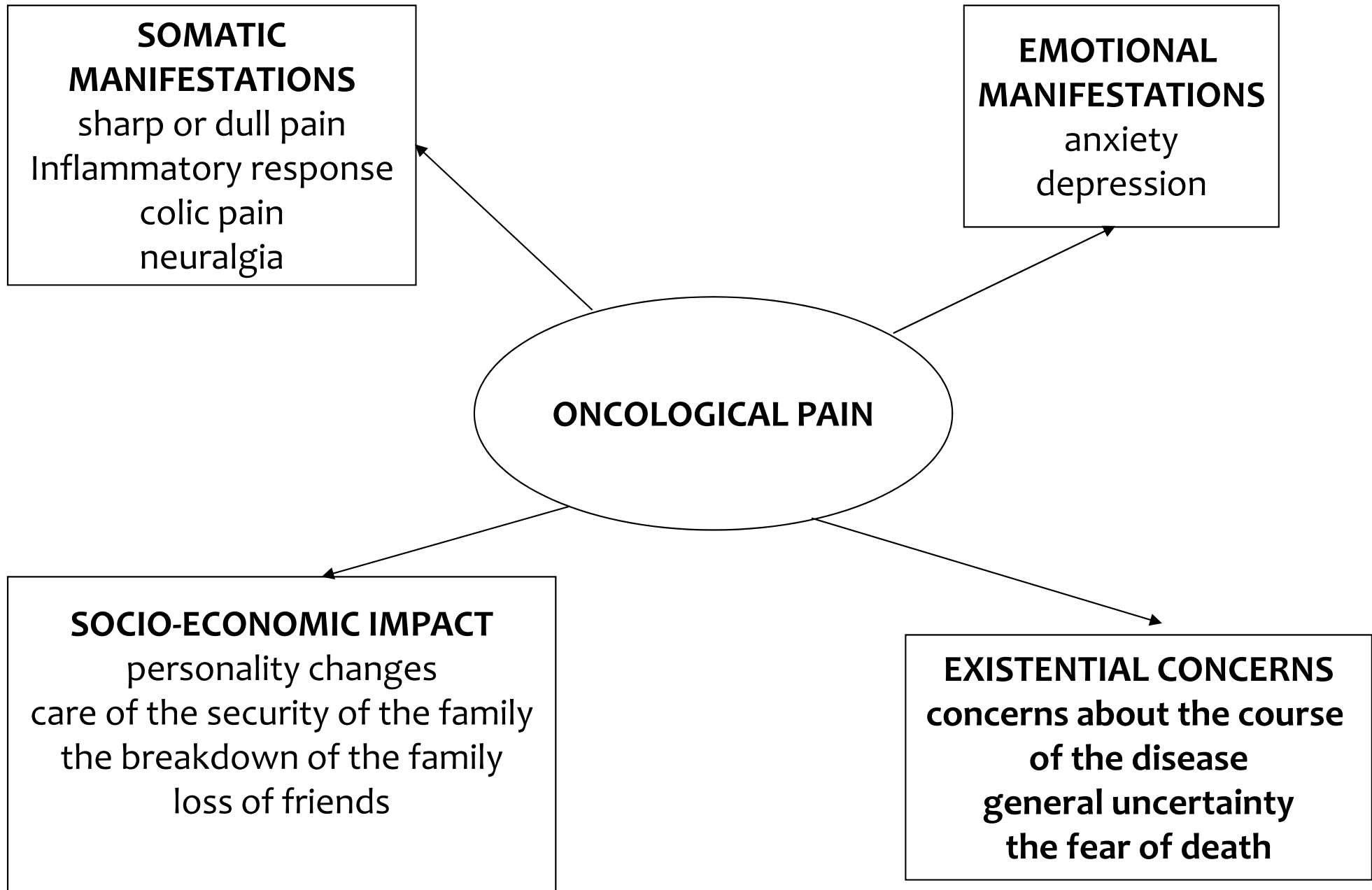
sudden, transient, mostly short-term worsening of pain in patients who have well-controlled baseline pain;

usually in patients treated with opioids for cancer diagnosis; typically in progression of cancer

# Special types of pain

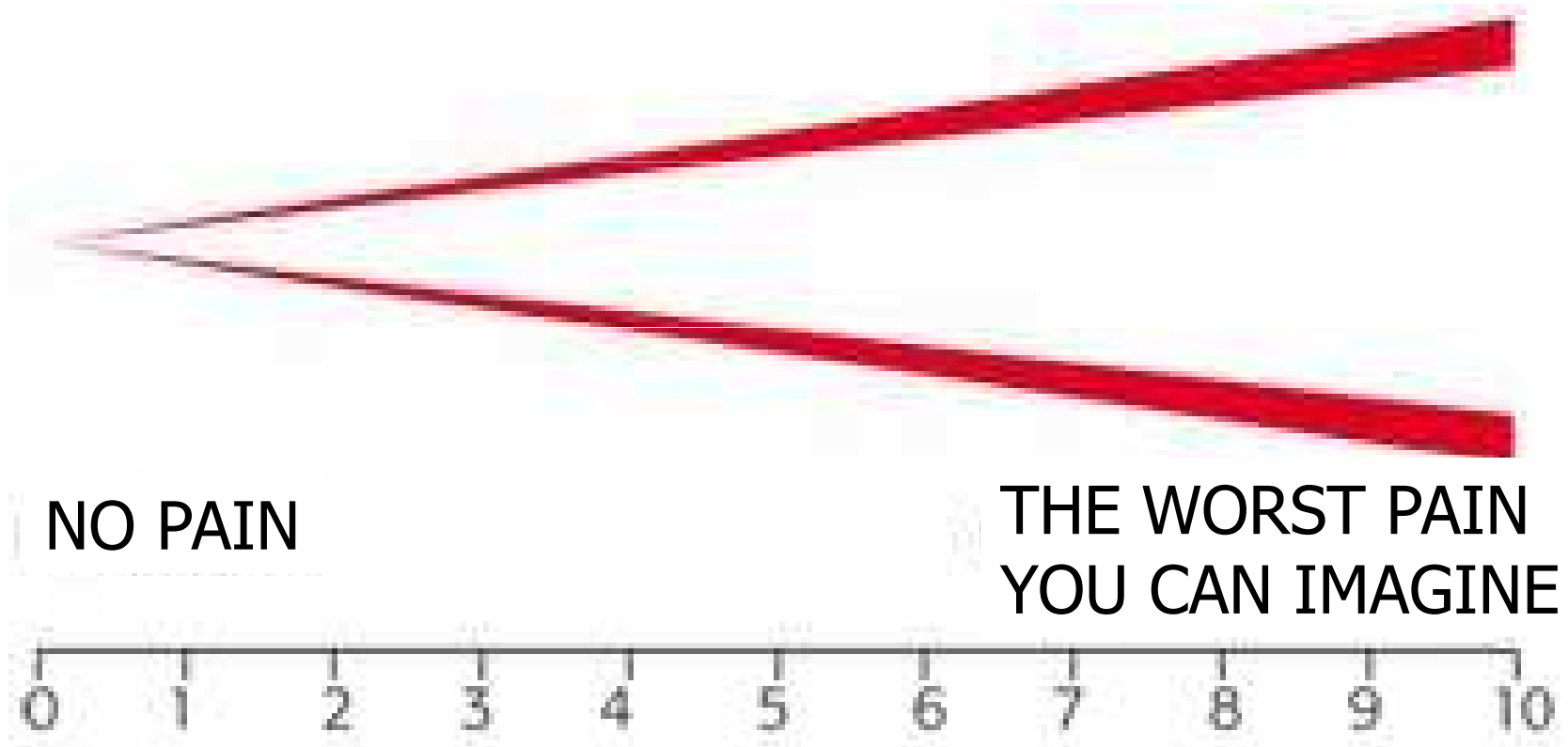
## ■ delivery pain

- belongs to the strongest pain reliever, nevertheless, that before the birth are rising thresholds for somatic and visceral pain
- the tissue is developed by excessive pressure, they are strongly being pushed and lacerations occur
- tissues are under influence of bradykinin,  $H^+$ ,  $K^+$ , histamine and serotonin
- induction of stress  $\rightarrow$   $\uparrow$  cortisol, epinephrine, norepinephrine, dopamine  $\rightarrow$  somatic and psychological reactions

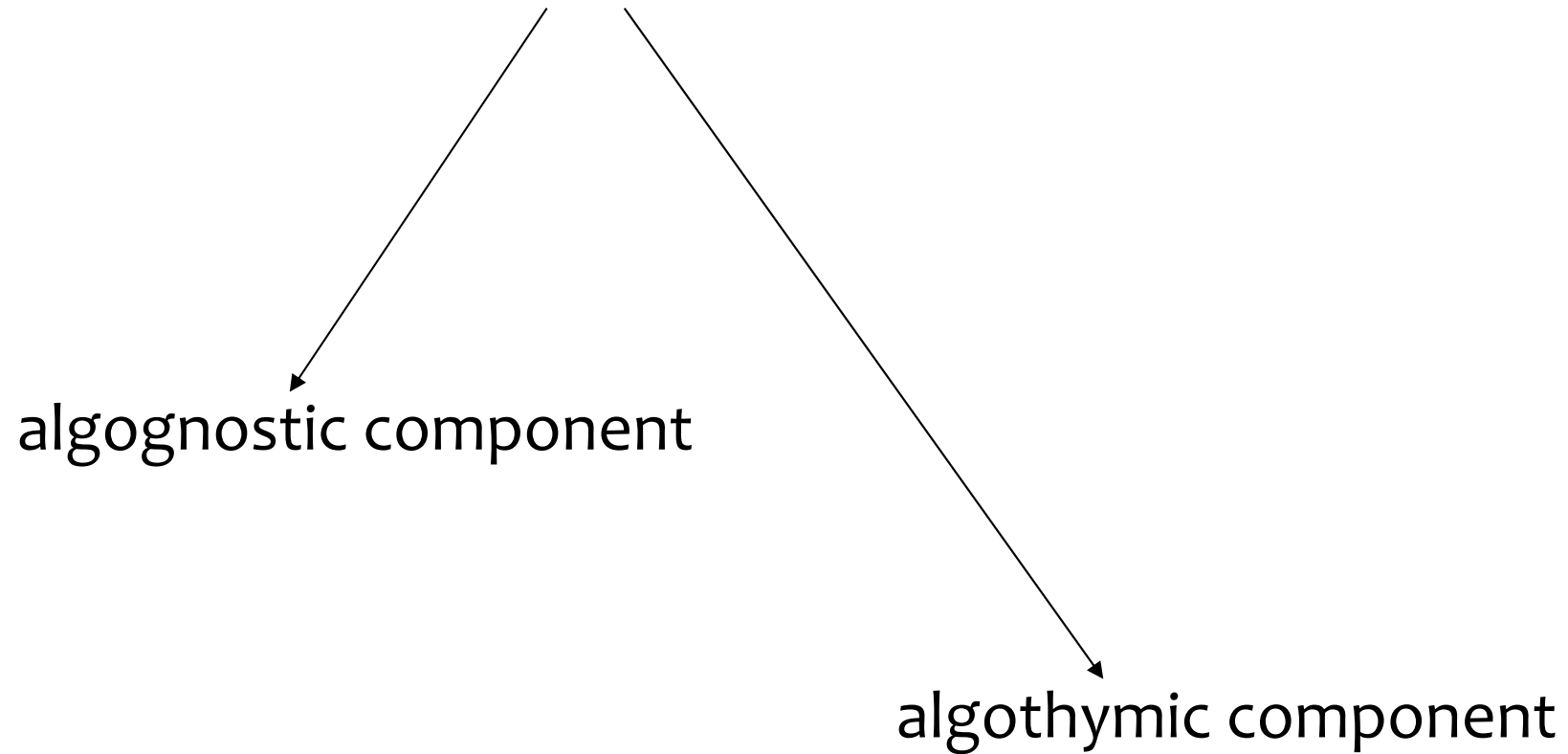


# Diagnosics of Pain

## VAS: Visual analogue scale



# Process of pain perception



# Pain – causes and mechanism

tissue damage → production of prostaglandines and other substances → effects on the free nerve endings → transduction of signal up to the brain neurons ⇒ **PAIN**

## Mediators of pain

(act on the nociceptors = pain receptors)

„algogenic substances“

bradykinin ——— + ——— ↑PGE (mediators of inflammation), increase sensitivity of nociceptors

histamine

acetylcholine

substance P (pain)

# Pain – causes and mechanism

**Endogenous pain suppressing (analgesic) substances:**

endorphins

enkephalins

dynorphins

binding to  $\alpha_2$  and NMDA receptors



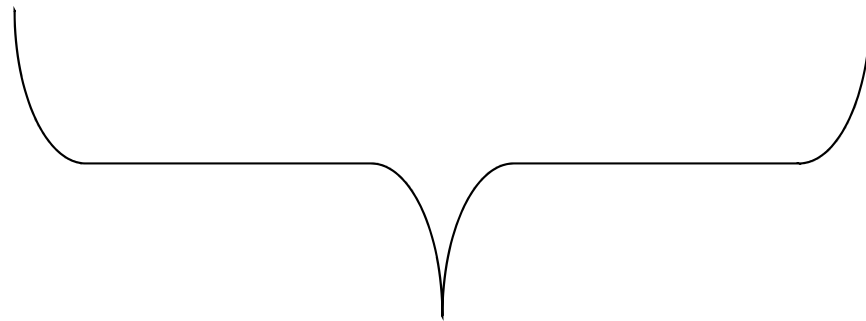
# Pain transduction – 3 neuron`s tract

## MAIN PAIN PATHWAYS

*tractus spinothalamicus*  
(spinothalamic tract)

vs.

*tractus spinoreticulothalamicus*  
(spinoreticulothalamic tract)



the tracks leading from the spinal cord (spinal ganglia) to specific areas of the brain (finally to the cerebral cortex) information about pain is received and processed

# Pain transduction – 3 neuron`s tract

- **spinothalamic tract** – 3 neuron`s phylogenetically younger pathway
  - sharp, well localized pain
- **spinoretikulothalamic tract** – phylogenetically older polysynaptic system, impulses are transmitted to the higher centres through short axonal pathways
  - dull, poorly localized pain
- vegetative response: blood pressure change, tachypnea, mydriasis, diaphoresis, increased muscle tone,...

# Pharmacological modulation of pain

Analgesics – anodynes (opioids)

Non-opioid analgesics (analgesics – antipyretics → NSAIDs)

Local anaesthetics

General anaesthetics

Adjuvant therapy (antidepressants, neuroleptics - antipsychotics, antiepileptics - anticonvulsants, antimigranics, central/peripheral myorelaxants, corticoids, bisphosphonates, caffeine... )

# Pharmacological modulation of pain

Analgesics – suppress perception of pain (increase the pain threshold) selectively without influencing perception of other stimuli

## **analgesics – anodynes (opioids)**

act on spinal and supraspinal level, cause effects on somatic and visceral pain, strong effects on consciousness, act substantially more strongly than non-opioid analgesics

## **non-opioid analgesics**

mostly peripheral effects (some have central effects!), effects on inflammation, weaker effects in general, no effects on visceral pain, no addiction

# Analgesics - anodynes

blocking transmission of pain signals between cells of the CNS (in the spinal cord, brain), as well as endogenous opioids:

**endorphins, enkephalins, dynorphins**

→ binding to opioid receptors (agonists)

## **Opiates**

substances similar structurally to morphine with analgesic effect (natural origin, currently produced synthetically)

## **Opioids**

+ synthetic, semisynthetic and endogenous opioid peptides + exogenous opioid analgesics

# Opioid receptors - $\mu$ $\kappa$ $\delta$ ( $\sigma$ )

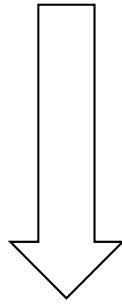
- G-protein coupled
- the interaction of the opioid with receptor  $\rightarrow$  G- protein inhibition  $\rightarrow$  reduction of neurotransmitter release + inhibition of neuronal activity
- adenylyl cyclase inhibition, facilitation of  $K^+$  channels opening postsynaptically, inhibition of  $Ca^{2+}$  channels opening presynaptically

- $\mu$
- $\kappa$
- $\delta$
- ( $\sigma$ )

# Opioid receptors - $\mu$ $\kappa$ $\delta$ ( $\sigma$ )

- $\mu$  – supraspinal analgesia, euphoria, sedation, miosis, breath depression, addiction, GIT effects
- $\kappa$  – spinal + peripheral analgesia, sedation, dysphoria, miosis, GIT effects, (somatic addiction)
- $\delta$  – spinal analgesia, breath depression, inhibition of GIT motility
- [ $\sigma$  – dysphoric effect, psychotomimetic effect (hallucinations, perception disturbances), anxiety]

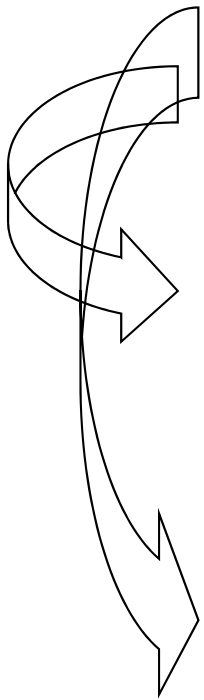
# Opioid receptors - $\mu$ $\kappa$ $\delta$ ( $\sigma$ )



**FOR ANALGESIC EFFECT IS CRUCIAL ESPECIALLY  
ACTIVATION OF RECEPTORS:**

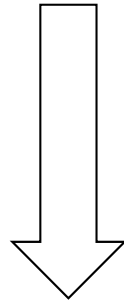
$\mu$  – supraspinal analgesia

$\kappa$  – spinal + peripheral analgesia





# Opioid receptors - $\mu$ $\kappa$ $\delta$ ( $\sigma$ )

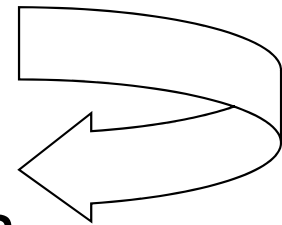
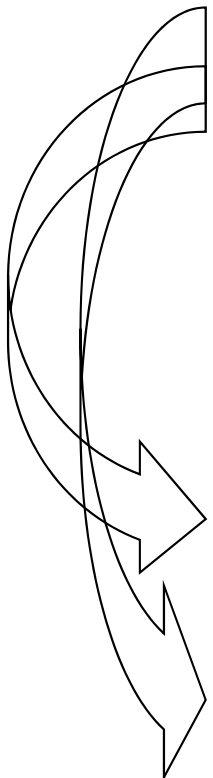


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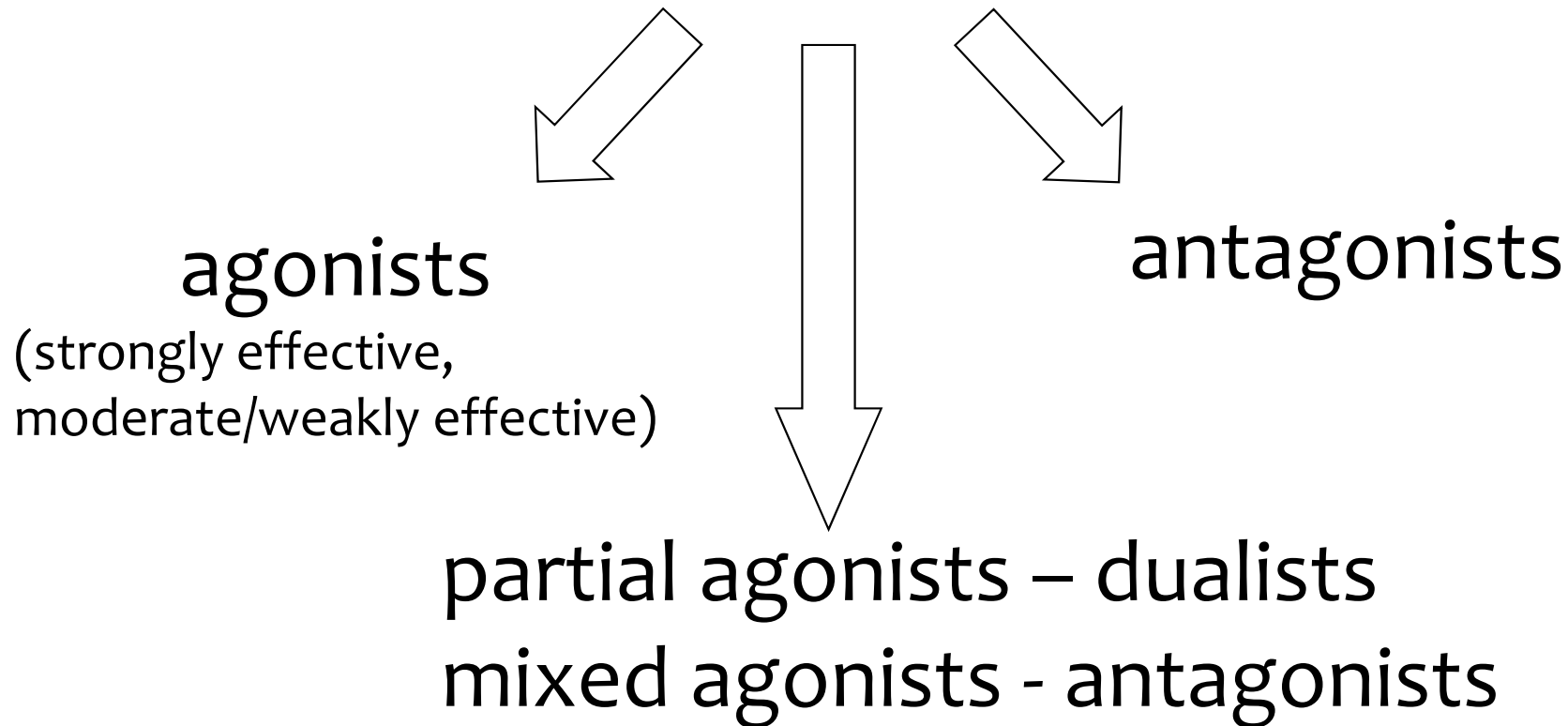
**FOR ADDICTION IS CRUCIAL ESPECIALLY ACTIVATION  
OF RECEPTORS:**

$\mu$  – supraspinal analgesia, euphoria

$\kappa$  – spinal + peripheral analgesia



# Pharmacological influence on opioid receptors



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Atypical opioids

# Pharmacological effects of analgesics - anodynes

## CENTRAL:

analgesic

suppression of respiratory center

sedation (+-)

suppression of anxiety

euphoria/dysphoria

antitussive effect

nausea and vomiting

↑ tendency to convulsions/cramps

miosis

↑ secretion of ADH,

↓ GnRH, corticotropine, FSH, LH, ACTH, cortisol, testosterone)

# Pharmacological effects of analgesics - anodynes

## **TOLERANCE !!!**

(to all effects of opioids except constipation and miosis!)

## **ADDICTION !!!**

# Pharmacological effects of analgesics - anodynes

## PERIPHERAL:

- decrease intestinal motility, slowdown propulsion of GIT content
- increase muscle tone of GIT and urinary bladder
- increase sphincter tone of gall bladder and urinary bladder
- constriction of pyloric sphincter, delayed gastric emptying
- vasodilation, orthostatic hypotension
- histaminoliberation
- inhibition of ciliated epithelium
- urological tract – increase tone of renal pelvis, ureter, *m. detrusor* and sphincter of bladder... urine retention, especially in post-operative conditions
- uterus - ↓ tone and motility, may prolong labor

# Pharmacokinetics of analgesics - anodynes

## ABSORPTION

parenteral

oral („first pass effect“ !!!)

perrectal

transdermal

sublingual

transmucous (nasal)

## DISTRIBUTION

parenchymatous organs

muscles

adipose tissue (lipophilic drugs → e.g. fentanyl)

pass well across BBB → brain (fentanyl,  
heroin,..)

*Can cross placental barrier !!!*

# Pharmacokinetics of analgesics - anodynes

BIOTRANSFORMATION primarily in liver



polar metabolites

- inactive metabolites
- active metabolites (codeine, tramadol, morphine...)

EXCRETION

- kidneys - urine
- liver - bile

# Opioid agonists

## morphine

- 10 % of opium content, together with codeine, thebaine + other phenanthrene alkaloids
- isolated in 1803 (Sertürner)
- high affinity to  $\mu$  receptors – selective  $\mu$  agonism



# Opioid agonists

## morphine

- see above effects
- application routes:
- orally (also p.o. with sustained release)
- parenterally (i.v., i.m., s.c., epidural,... )
- perrectally

**Indications:** chronic cancer pain, pain after surgery, injuries, (pain during acute myocardial infarction → today, given preference to other opioids)

# Other strong opioid analgesics

## methadone

- less sedation and euphoria than in morphine
- ↑ bioavailability after oral administration, ↑  $t_{1/2}$
- acts on opioid + NMDA receptors
- **Use:** addiction treatment (heroin) → 2 benefits
  - change from injection application to oral administration
  - ↑  $t_{1/2}$  decreases plasmatic fluctuation of methadone → less withdrawal symptoms

# Other strong opioid analgesics

## heroin (= diacetylmorphine)

- not used in clinical medicine (in Czech Republic)  
(but in Great Britain can be therapeutically used!)
- causes severe addiction; abused!
- heroin belongs to the most health and personality devastating substance!!!

# Other strong opioid analgesics

## fentanyl, sufentanil, remifentanyl,...

- pass well across HEB (↑ concentrations in CNS)
- strong, short analgesia (fentanyl 100 x more potent than morphine, sufentanil 1000 x more potent than morphine)
- strong respiratory depression!, ↓ emetogenic potency, CAVE → can cause muscle rigidity
- risk of serotonin syndrome in combination with 5-HT<sub>2A</sub> agonistic drugs

# Other strong opioid analgesics

**fentanyl, sufentanil, remifentanyl,...**

- Indications, use:

- **in anaesthesiology** → neuroleptanalgesia

(= neuroleptic (AP) + opioid)

→ analgosedation (e.g. opioid + BZD)

- therapy of strong pain – acute myocardial infarction, cancer pain,...

- fentanyl in TTS (↑ duration of action – can be used in chronic cancer pain), transmucous (can be used in breakthrough pain)

# Other strong opioid analgesics

## piritramid

- less respiratory depression than morphine
- less emetogenic potency
- usually well tolerated parenteral administration
- **Use:** therapy of acute strong pain, e.g. after surgery (PCA), acute myocardial infarction, pain after injuries,...

**Others:** oxycodone, hydromorphone (not registered in Czech Rep.), oxymorphone (not registered in Czech Rep.)

**CAVE:** all strong opioids are prescribed to forms with blue band („opiate forms“), very strict accounted and subjected to the rules for handling with narcotics and psychotropic drugs and their precursors!!!

# Other strong opioid analgesics

## pethidine (=meperidine)

- ↓suppression of respiratory center than morphine
- ↓analgesic potency than morphine (5-10 x weaker)
- metabolite norpethidine is proconvulsive and causes hallucinations
- administration orally and parenterally

**Indications:** cancer pain, pain after injuries, pain during acute myocardial infarction, pain after surgery, premedication before general anaesthesia... today not often used (high risk of abuse, hallucinations!)

# Opioid agonists (moderate and weak potent)

## codeine

- 10 % mtb. to morphine
- antitussive effect in subanalg. doses
- analgesic effect in combinations (paracetamol, ASA)

*analgesic potency: codeine 50mg ~ ASA 1g*

- ↓ risk of addiction than strong opioids
- CAVE ↑ risk of addiction of combined (compositive) analgesics
- causes obstipation
- not used in children!!!



# Opioid agonists (moderate and weak potent)

## dihydrocodeine

- suitable in pains combined with cough (this co-incidency is not necessary for dihydrocodeine indication)
- in Czech Rep. dihydrocodeine in sustained release drug form (effect 12 h) → indication for chronic moderate and strong pain

Side effects: obstipation, ↑liver tests, histaminoliberation

**CAVE: codeine and dihydrocodeine are prescribed to normal forms - without blue band!**

# Partial agonists + mixed agonists - antagonists

- lower affinity to  $\mu$  receptors, high affinity to  $\kappa$  rec.,
- respectively  $\kappa$ -agonists -  $\mu$ -antagonists or partial  $\mu$  receptor agonists (buprenorphine)
- less potential for addiction, but exists!
- lower analgesic effect than full agonists
- less side effects than full agonists

Partial agonists

Mixed agonists - antagonists

# Partial agonists + mixed agonists - antagonists

## buprenorphine

- partial  $\mu$  rcp. agonist
- ↓tolerance in comparism with other opioids
- ↓abuse potential, obstipation and other GIT effects
- ↑ „first pass effect“ ! Do not administer orally!!!
- **Use:** 1) strong chronic pain (TTS!)  
2) substitution therapy of opioid (heroin) addiction → combined with opioid antagonist naloxone in one drug form (sublingual) → in injection application naloxone antagonizes effects of buprenorphine (in sublingual administration naloxone does not act!)

Partial agonists

Mixed agonists - antagonists

# Partial agonists + mixed agonists – antagonists – other representatives

- mixed agonists – antagonists
- usually  $\mu$ -antagonists and  $\kappa$ -agonists (event. also  $\delta$ -agonists)
- possibility of  $\sigma$ -receptor activation  $\rightarrow$  psychotomimetic and hallucinogenic effects)
- analgesic effects are weaker than full agonists
- today minimal use
- **pentazocin, butorfanol** – in Czech Rep. not registered

Partial agonists

Mixed agonists - antagonists

# Partial agonists + mixed agonists – antagonists – other representatives

## nalbuphine

- for short-term therapy of moderate and strong pain
- unsuitable for long-term therapy
- parenteral administration (i.v., i.m., s.c.)
- causes respiratory depression comparable to morphine, but suppression of respiratory center has drug ceiling effect
- **Use: perioperative pain, suppression of pain in obstetrics (BE AWARE: in newborns risk of breathing depression, bradycardia, cyanosis and hypotension → newborn`s monitoring necessary!)**

Partial agonists

Mixed agonists - antagonists

# Atypical opioids

## tramadol

- low affinity to  $\mu$  receptors + norepinephrine and serotonin reuptake inhibition (= atypical mechanism of action, similar to some antidepressants from SSRI group; effect of tramadol can not be fully antagonized by opioid antagonists)
- approximately 1/6 – 1/10 of morphine analgesic potency
- very suitable combination with paracetamol
- less side effects (minimal respiratory depression)
- risk of serotonin syndrome
- in Czech Rep. very often prescribed analgesic, prescription to normal forms without blue band; more drug forms
- RISK OF ADDICTION!!!

**Use:** therapy of moderate and strong pain (acute and chronic)

# Atypical opioids

## tapentadol

- dual mechanism of action
  - $\mu$  agonist + NRI (+  $\sigma$  agonist)  
NEW GROUP – MOR-NRI ( $\mu$  receptor agonism – noradrenaline reuptake inhibitor)
- more effective than tramadol, analgesia comparable with oxycodone, but less adverse effects
- suitable for the treatment of acute (but also chronic pain – e.g. vertebrogenic; also effective in diabetic neuropathy - neuropathic pain!!!)
- relatively few adverse effects (compared to classical strong opioids, e.g. oxycodone)
- p.o. administration (also tbl. with sustained release)

**CAVE: tapentadol is prescribed to forms with blue band („opiate forms“), very strict accounted and subjected to the rules for handling with narcotics and psychotropic drugs and their precursors!!!**

# Antagonists of opioid receptors

**naloxone, naltrexone**

**Indications:** treatment of opioid intoxication, treatment of respiratory depression induced by opioids, addiction diagnostics (withdrawal symptoms)



**TRIAD:** coma, respiratory depression, miosis

Opioid antagonists



# Antagonist / partial agonist

**nalmefen**

antagonist  $\mu, \delta$ , partial K agonist

„controlled drinking“

Opioid antagonist/partial  
agonist

# Opioid-induced side effects

- **respiratory depression (suppression of breathing)**
- **nausea and vomiting**
- **sedation, inhibition of cognitive functions**
- **constipation** (solution = oxycodone + naloxone)
- **ADDICTION**
- **be careful in pro-convulsive states! (e.g. epilepsy – proconvulsive action – decrease of the threshold for seizures)**
- **↑ intracranial pressure**

# Intoxication by opioid agonists

nausea, „flush“, tinnitus

apathy, sedation, sleep, miosis

superficial breathing

cyanotic, cold skin, tachycardia

asphyxia

**TRIAD:** coma, respiratory depression, miosis

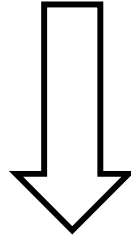
## **Treatment:**

naloxone i.v.

ventilation, vital functions,

parenteral liquids in unconsciousness

# Withdrawal symptoms



occur approximately after 3-4 weeks of opioid administration

„craving“ („drogenhunger“), „craving“ for the another dose  
(psychic addiction arises easiest to heroin, oncology patients  
treated with opioids → < 1% of patients)

unrest, depression

anxiety, weakness, nervousness, mydriasis

lacrimation, ↑ nose secretion, frisson (goosebumps),

↑ perspiration, pain, stenocardia

# Rules of pain therapy management

- Choice and course of analgetic therapy depends on intensity and character of pain described by the patient – individual dosing – titration may take weeks in CHP
- Acute pain – course - from up going down – start with strong medication (opioid), parenteral administration, fast onset (eg. pain in AIM, renal or biliar colic)
- In chronic pain – course – from down going up – non-invasive preparations (p.o., TTS), slower release according to a time plan
- In some types of fluctuating chronic pain it may be necessary to give patient rescue medication in case of breakthrough pain

# Rules of pain therapy management

- Combination of non-opioid and opioid analgesics has additive effect
- Benefits of analgesic therapy should exceed its side effects.
- AE must be prevented rather than treated when they appear – eg. antiemetics, diet, laxatives
- There is not a maximal dose of opioid – (in case of full agonists and cancer pain)
- Rotation of opioids

# Rotation of opioids

- Switch in case of AE
- Sometimes even in equianalgesic dose increase of effect

# General rules of pain pharmacotherapy management

## ■ WHO's pain relief ladder

### ● Step 1 (VAS 0-4)

- non-opioid analgesics ± adjuvant treatment

### ● Step 2 (VAS 4-7)

- pain persists, intensifies, no change in the objective finding
- weak/moderate opioid analgesics ± non-opioid analgesics ± adjuvant treatment

### ● Step 3 (VAS 7-10)

- pain persists, intensifies, there is no indication for another treatment
- strong opioid analgesics ± non-opioid analgesics ± adjuvant treatment ± weak/moderate opioid analgesics



# Other indications of opioids

- **antitussive effect**
  - can be induced by **codeine** and **dextromethorphan** in dry non-productive cough
- **constipative effect**
  - can be induced by **loperamide** and **diphenoxylate** in functional diarrhea
- **premedication before anaesthesia and surgery under general anaesthesia**
  - leads to calm the patient and based on the synergism of drugs reduces the total dose of narcotics (thereby increasing the safety of anaesthesia)
  - particularly fentanyl and its derivatives are used
  - combination of opioid analgesic with neuroleptic (fentanyl + droperidol) within neuroleptanalgesia
- **replacement (substitution) therapy of addiction to heroin or other opioids – methadone, buprenorphine**