On-farm killing of pigs

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Main topics according to the discussions on day 1

I. **Methods for the stunning and killing of non-viable pigs and piglets on farm**

- Information about technical equipment
- With special consideration to one-step killing methods (without debleeding)

II. **Methods for the mass depopulation of pigs** in case of a disease outbreak (e.g. African Swine Fever)

- gas killing methods: type of containers, technical parameters like gas concentration and exposure time, animal categories

III. **Process control and safeguarding animal welfare**

- Key parameters according to the Council Regulation No. 1099/2009
- Animal-based measures for the state of consciousness and death

Methods for on-farm stunning and killing of pigs (overview)

Physical methods		Chemical methods	
Mechanical methods	**Electrical methods**	**Inhaled methods**	**Noninhaled methods**
✓ Penetrative captive bolt		✓ Gas mixtures	Lethal injection *(Its use is reserved to veterinarians!)*
✓ Non-penetrating captive bolt	Electrocution for killing pigs during disease outbreak	✓ Gas-filled foam	Stunning/killing in groups → use for mass depopulation of pigs during disease outbreaks
✓ Percussive blow to the head			
✓ Firearm with free projectile			

Individual stunning/killing, e.g. of non-viable pigs at farm level

Knowledge and skills of the operator are crucial for a successful performance of the methods with regard to animal welfare.

Mechanical methods

(EFSA, 2020a; Lambooij and Algers, 2016; EFSA, 2004)

Penetrating methods	Non-penetrating methods
Penetrative captive bolt	Non-penetrating captive bolt (controlled blunt force trauma)
Firearm with free projectile	Percussive blow to the head (manual blunt force trauma)

<u>Operating principle</u>

- ✓ Brain concussion (with coup-contre-coup-effect)
- ✓ Brain haemorrhages
- ✓ Immediate unconsciousness

- ➢ Penetrating mechanical methods: prolonged unconsciousness due to
  - ➢ Structural damage of brain tissue with haemorrhages
  - ➢ Pressure waves within the fluid medium of the brain

Penetrative captive bolt

For pigs cartridge-driven captive bolt guns are used (EFSA, 2020a, 2004).

Difficult application on pigs (EFSA, 2020a, 2004):

1. small target area
2. deep position of the brain in the head with a mass of sinuses lying between the frontal bone and the brain cavity
3. different skull shapes according to breeds

Penetrative captive bolt (EFSA, 2020a; LWK Nds. et al., 2018; LAVES, 2015; EFSA,2004; HSA, 2013)

Shooting position: perpendicular to the parietal bones, in the midline of the forehead, 1-2 cm above eye level, with the muzzle placed against the head and directed towards the tail

Depending on different head shapes:

- ✓ Wedge-shaped head: 1 cm above eye level (as described above), with 25° angulation of the device (tilting it slightly down)
- ✓ Steep head: 2-3 cm above eye level, with a right-angled base of the device

Sows, boars: ridge of bones →3-4 cm above the eyes with the muzzle placed slightly to the side of the midline aiming at the centre of the head

- ➢ use of another method recommended esp. for boars with clearly pronounced sinuses and thus a very deep position of the brain in the skull

Penetrative captive bolt (Meier, 2020; Woods, 2012)

Two-step method → subsequent killing method is necessary

Recent studies on the use of different bolt guns on animals of different weight classes as a single-step euthanasia method:

- Woods (2012): „Cash Dispatch Kit" (Accles & Shelvoke, UK) → pigs up to 200 kg
- Meier (2020): two partly modified captive bolt guns, „Ferkelblitz" for piglets up to 5 kg and „Blitz-Kerner" for piglets > 5 kg (Turbocut Jopp GmbH, Germany) → pigs up to 30 kg

According to the law, after the captive bolt shot, even with these devices, a killing procedure must still follow in principle and until now.

Penetrative captive bolt (EFSA, 2020a; LAVES, 2015)

Further requirements:

Good restraint of the animal (minimise head movements, ensure adequate shooting position and direction)

Suitable device (bolt length and diameter) and cartridge (bolt velocity) depending on animal category and age

Dry storage of cartridges

Daily inspection and cleaning of the device before and after its use (removal of contaminations and rust; sharpness of the bolt, retraction system)

Maintenance of the device by the manufacturer at least every two years

Penetrative captive bolt

Key parameters according to Council Regulation No. 1099/2009:

- Position and direction of the shot
- Appropriate velocity, exit length and diameter of bolt according to animal size and species (adequate captive bolt parameters)
- Maximum stun to stick/kill interval(s)

Firearm with free projectile (EFSA, 2020a; HSA, 2016)

One-step killing method

Minimal or no restraint of the animal; used to kill pigs from a distance

shooting at close range with handguns (from a distance below 10 cm) and shotguns (from a distance between 5 and 25 cm)

Shooting position: the same as for captive bolt

Sufficient kinetic energy of the projectile is necessary (penetration depth, sufficient damage to the brain, brain concussion, instantaneous death)

Ideal ammunition: bullets constructed to fragment and/or deform within the skull

Work safety: ricochet of free bullets (when use in enclosed spaces, hard surfaces)

Firearm with free projectile

Key parameters according to Council Regulation No. 1099/2009:

- Position of the shot
- Power and caliber of the cartridge
- Type of projectile

Non-penetrating captive bolt (EFSA, 2020a; Grist et al., 2018a, 2018b, 2017)

Cartridge-driven or pneumatic non-penetrating captive bolt guns (N-PCBG)

Create controlled blunt force trauma

Recent studies support the use of N-PCBG as single-step killing method for neonatal piglets:

Grist et al. (2017, 2018a)-Zephyr EXL (Bock Industries): Kinetic energy of 27.7 J (120 psi), piglets up to 10.9 kg, restraint of the piglets`head on a hard surface is decisive

Grist et al. (2018b) – CASH Small Animal Tool (Accles & Shelvoke, UK): kinetic energy 47 J (brown 1-grain cartridge), restraint in a hammock, piglets up to 5 kg

Non-penetrating captive bolt

Key parameters:

- Position and direction of the shot
- appropriate velocity, diameter and shape of bolt according to animal size and species (captive bolt parameters)
- Strength of the cartridge used or applied air pressure (in psi)

According to the Council Regulation No. 1099/2009, until now, the application of non-penetrating captive bolt guns is not allowed for pigs!

Percussive blow to the head (EFSA, 2020a; LWK Nds. et al., 2018; Woods and Shearer, 2015, TVT, 2014)

Two-step method → subsequent killing method is necessary

Acceptable for piglets up to 5 kg

Manually applied blunt force trauma, by hitting the head once with a ball peen hammer, steel rod, wooden club or pipe with sufficient strength and precision

Location: at the highest point between the eyes and the base of the ears

The object needs to be brought to the animal`s head, not the animal to the object; no application over the edge of the pen wall !!

Percussive blow to the head

Key parameter according to the Council Regulation No. 1099/2009:

- Force and location of the blow

Low reproducibility, questionable reliability and effectiveness → replacement by other methods is recommended

Electrical killing methods (EFSA, 2020a; AVMA, 2020; LWK Nds. et al., 2018; Woods & Shearer, 2015, EFSA, 2004)

Two kinds of electrical killing methods:

1. two-step method with head-only electrical stunning followed by ventricular fibrillation

2. one step-euthanasia method of head-to-body-application

Effect: grand mal seizure (unconsciousness), followed by ventricular fibrillation (cardiac arrest → death)

Electrical killing: two step-method (EFSA, 2020a; TVT, 2018, LWK Nds. et al., 2018; EFSA, 2004)

First current cycle (head-only stunning):

Electrodes → head:between eyes and base of ears; application from behind, at least 1.3 A for 4 s (heavy pigs: 1.8 A)

Prevention of pre-stun electrical shocks

→ Adequate restraint of the animal; maintaining electrical contact during collapse of the animal by the operator

Second current cycle (heart):

Currents with frequencies of 50 Hz for at least 8 s; electrodes: from head to sternum or from back to the chest or left and right of the ribs directly behind the shoulder blade

Electrical killing: one step-method (EFSA, 2020a; Lambooy and van Voorst, 1986)

Head-to-body-electrodes (spanning the head and heart at the same time)

Injection of sedative drugs (e.g. azaperone) for agitated pigs, if necessary

Adequate restraint for right placement of electrodes for sufficient duration of current application until death

Lambooij and van Voorst (1986): mobile electrocution unit for mass depopulation of swine (MPS/Marel) older than 1 week

- Conveyor belt as negative electrode, three chain curtains as positive electrodes

Electrical killing: electrocution of piglets up to 2 kg

Husheer (2017):

skin penetrating needle electrodes (size of 1 x 2 cm²) combined with electrode gel

Application of a current of 0.75 A at a frequency of 400 Hz first laterolateral through the thorax for 5 s and after a break of 20-30 s dorsoventral through the thorax for 5 s

Electrical killing methods

Key parameter according to the Council Regulation No. 1099/2009:

- Stunning parameters (minimum current, voltage, frequency, time to exposure)
- Frequency of calibration of the equipment
- Optimisation of the current flow
- Prevention of electrical shocks before stunning
- Position and contact surface area of electrodes

Inhalant methods: CO_2 (EFSA, 2020a; Woods and Shearer, 2015; Troeger, 2008; EFSA, 2004; Raj & Gregory, 1995; Gregory et al., 1990; Nattie, 1999; Cantieni, 1977; Eisele et al., 1967; Woodbury and Karler, 1960)

On farm level: precharged systems for piglets

80 %, preferably 90 % CO_2 for at least 10 minutes

One-step method

Advantages: stun/kill in groups, minimum amount of restraint and handling

Disadvantage: effect of CO_2 and delayed onset of unconsiousness

1. Painful mucosal irritation in upper airways
2. Respiratory distress: stimulation of the chemosensible respiratory centre, increased respiration rate (hyperventilation) → conscious perception as breathlessness within the first 10-20 s

Inhalant methods: CO_2 for mass depopulation of pigs (Gerritzen et al., 2012; EFSA, 2004; EFSA, 2020a,b)

Containerised gassing systems

- 90 % CO_2 in air (3 min)
- Argon, nitrogen and mixtures, 2 % residual oxygen (7 min)
- 30 % CO_2 in argon or nitrogen (7 min)

Inhalant methods: CO_2

Key parameter according to the Council Regulation No. 1099/2009:

- Carbon dioxide concentration
- Duration of exposure
- Quality and temperature of the gas

Inhalant methods: high expansion gas-filled foam (EFSA, 2020a; Wallenbeck et al., 2020; Balzer, 2017)

high expansion foam filled with nitrogen

Principle: foam burst upon contact with the animal and surrounding materials, released gas results in stunning/killing of the animal

- Balzer (2017): first application on moribund suckling piglets in an open system showed no advantages to CO_2, latency period until last movement 296.8±155.33 s, no rapid onset of death
- Wallenbeck et al. (2020): use of foam in closed system with modification of foam supply and foaming agent on heavier pigs (27.8 ± 3.4 kg); increased escape attempts with increasing foam level (avoidance behaviour), loss of posture at 57.9 s, end of convulsions after 131.2 s; animals were unconscious or dead within 5 min after start of foam production

Inhalant methods: gas-filled foam

Further research on the emergency killing of piglets with investigations on the assured killing effect of the process

Possible key parameters:

- Bubble size (to prevent trachea displacement)
- Residual oxygen
- Expansion rate
- Sufficient foam production rate
- Gas source and gas purity
- Foam concentration
- Gas and water temperature

Animal-based measures for the state of consciousness and death

(EFSA, 2020a; Holmes et al., 2020; EFSA, 2013)

Animal-based measures (ABM) are measurable and objective outcome-based criteria to evaluate welfare.

Important welfare consequences in the on-farm killing process corresponding to the state of consciousness: **pain and fear**

Pigs might experience pain and fear during ineffective killing

a) With persistence of consciousness (stun failure) and/or

b) During recovery of consciousness before death (re-awakening of the animals).

ABM related to the state of consciousness after application of physical methods (EFSA, 2020a; EFSA, 2013)

ABM : state of consciousness (pain and fear as welfare consequences)	**Outcome in effectively stunned animals (low risk of pain and fear)**	**Outcome in ineffectively stunned or re-awakening animals (high risk of pain and fear)**
Posture	Loss of posture, immediate collapse	Fail to collapse, attemptions to regain posture after collapse
Breathing	Absence of (rhythmic) breathing, apnoea	Rhythmic breathing
Tonic/clonic seizures	Onset of tonic-clonic seizures soon after collapse	Fail to show tonic/clonic seizures
Corneal and palpebral reflex	Corneal and palpebral reflex are not present (temporarily positive corneal reflex after electrical and penetrative captive bolt stunning	Blinking in response to the stimulus during testing the palpebral and cornealreflex
Vocalisation	No vocalisation	Vocalisation is possible (cave: not all conscious animals may vocalise)
Eye movements	Fixed eyes (wide open and glassy eyes with clearly visible iris/cornea in the middle); obscured eyeballs owing to rotation in the eye socket	Eye movements: eye tracking to moving objects, spontaneous blinking

ABM related to death after application of on-farm killing methods

(EFSA, 2020a; EFSA, 2013)

Death needs to be monitored and confirmed repeatedly after applying the killing method and before disposal of the carcass.

ABM : state of death (pain and fear as welfare consequences)	**Outcome dead animals (low risk of pain and fear)**
Body movements	Relaxed body, loss of muscle tone
Breathing	Absence of breathing, apnoea
Corneal and palpebral reflex	Corneal and palpebral reflex are not present
Pupil size	Dilated pupil
heartbeat	No heartbeat

Toolboxes (EFSA, 2020a; EFSA, 2013)

EFSA (2020a, 2013) has combined the ABM for the assessment of consciousness and death in descriptive toolboxes for each procedure.

European Commission

Thank you for your attention. Do you have any questions?

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